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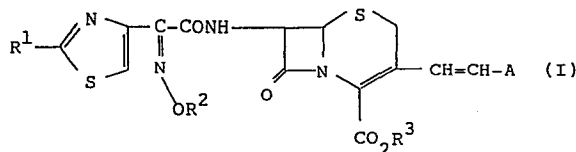
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New cephalosporin compounds and the production thereof.

A class of new cephalosporin compounds (syn-isomer) is now provided, which is useful as antibacterial agent and is represented by the general formula (I)



wherein R¹ is an amino group or a protected amino group; R² is a lower alkyl group, a carboxymethyl group or a protected carboxymethyl group; R³ is a hydrogen atom, a salt-forming cation or a carboxyl-protecting group; A is an unsubstituted or substituted phenyl group, an unsubstituted or substituted furyl group, an unsubstituted or substituted thiazolyl group or an unsubstituted or substituted 3-lower-alkylthiazolio group, and a pharmaceutically acceptable salt or ester thereof.

NEW CEPHALOSPORIN COMPOUNDS AND THE PRODUCTION THEREOF.

SUMMARY OF THE INVENTION

This invention relates to a new cephalosporin compound and a pharmaceutically acceptable salt or ester thereof which are useful as antibacterial agent. More particularly, this invention relates to a new cephalosporin compound (as syn-isomer) which bears an α -(substituted imino)- α -(2-aminothiazolyl)-acetyl group as a side chain at the 7-position and a β -substituted vinyl group as a side chain at the 3-position of the cephem nucleus. This invention also relates to a pharmaceutical composition comprising the new cephalosporin compound as active ingredient. This invention further relates to a process for the production of the new cephalosporin compound.

BACKGROUND OF THE INVENTION

Some β -lactam compounds which are closely related to the new cephalosporin compounds of this invention are known as disclosed in Japanese Patent Application first publication "Kokai" No. 124790/80, No. 122383/81 and No. 76088/84, and U.K. patent application first publication No. 2128990 A. These known cephalosporin compounds which are disclosed in said Japanese patent application first publications have a β -substituted vinyl group as the side chain at the 3-position of the cephem nucleus, similarly to the cephalosporin compounds according

to this invention. However, the new cephalosporin compounds of this invention are different from the above-mentioned known cephalosporin compounds in respect of the kind of the substituent born on the β -position of the β -substituted vinyl group at the 3-position of the cephem nucleus.

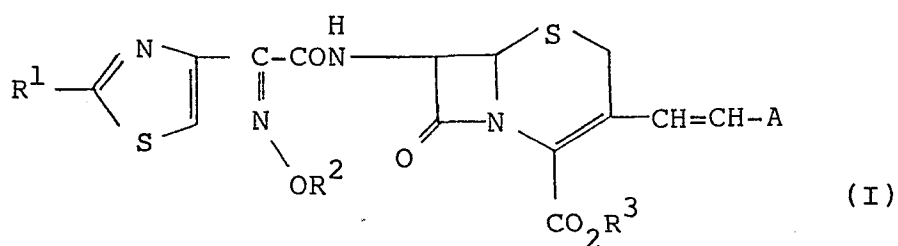
Cephalosprin-type antibiotics are known to be highly and broadly active against a variety of gram-positive and gram-negative bacteria. Various kinds of semi-synthesized cephalosporin compounds have already been available commercially and applied clinically for the therapeutic treatment of various infections diseases. But, only a very few ones amongst these semi-synthesized cephalosporin compounds are practically effective against the strains of bacteria of the genus Pseudomonas and Proteus. These known cephalosporin compounds are also degradable by a β -lactamase which is produced by some resistant strains of bacteria, and they exhibit only a poor activity against some resistant strains of bacteria which have now been a target of clinical treatments of bacterial infections (see: W.E. Wick "Cephalosporins and Penicillins, Chemistry and Biology", edited by E.H.Flynn, Academic Press, New York, N.Y., 1972, Chapter 11.)

We, the present inventors, have now succeeded in preparing as the new compound, cephalosporin compounds

represented by the general formula (I) as shown below, and we have found that said new cephalosporin compounds exhibit a very wide range of antibacterial sepctrum that these new compounds are highly active not only against a variety of gram-positive and gram-negative bacteria but also against some of resistant strains of bacteria. We have thus accomplished this invention.

DETAILED DESCRIPTION OF THE INVENTION

According to a first aspect of this invention, there is provided a new cephalosporin compound of the general formula (I)



wherein R^1 is an amino group or a protected amino group; R^2 is a lower alkyl group, a carboxymethyl group or a protected carboxymethyl group; R^3 is a hydrogen atom, a salt-forming cation or a carboxyl-protecting group; A is an unsubstituted or substituted phenyl group, an unsubstituted or substituted furyl group, an unsubstituted or substituted thiazolyl group or an unsubstituted or substituted 3-lower-alkylthiazolio group, and a pharmaceutically acceptable salt or ester of said cephalosporin

compound.

The cephalosporin compound of the formula (I) according to this invention includes two isomers, namely (E)-isomer (i.e., a trans-isomer) and (Z)-isomer (i.e.,
5 a cis-isomer), depending on the relative positions of the substituents and the hydrogen atoms attached to the vinylic double bond of the β -substituted vinyl group at the 3-position of the cephem nucleus. The cephalosporin compound of this invention, therefore, covers the (E)-isomer, the-
10 (Z) isomer and the mixture thereof. The (Z)-isomer of the cephalosporin compound according to this invention is of such a form in which the group A and the cephem moiety take "cis"-position around the vinylic double bond of the vinyl group at the 3-position as shown in the general
15 formula (I). The (E)-isomer of the cephalosporin compound is of such form in which the group A and the cephem moiety take "trans"-position around the vinylic double bond of the vinyl group at the 3-position of the cephem nucleus.

Some of the terms used in this specification have
20 the meanings as defined below:

The term "lower" means that an alkyl or alkoxyl or alkanoyl group concerned is containing 1 to 6 carbon atoms, unless otherwise stated. The amino-protecting group, such as the amino-protecting group present in the protected
25 amino group which R^1 may represent, includes a conventional

amino-protecting group which may easily be removed by acid hydrolysis, for example, an alkoxycarbonyl group such as tert.-butoxycarbonyl group; an acyl group such as a formyl group and a chloroacetyl group; and a trityl group.

5 The "protected carboxymethyl group" which R^2 represents is such a carboxymethyl group of which the carboxyl group has been protected by esterification with a lower alkyl group, e.g., methyl, ethyl, propyl, n-butyl and t-butyl or an aryl group such as phenyl or an aralkyl group
10 such as benzyl.

 The salt-forming cation which R^3 represents is a conventional metal cation and may include cation of an alkali metal, an alkaline earth metal and ammonium. Sodium cation is preferred. The carboxyl-protecting group
15 which R^3 represents is a carboxyl-protecting group conventionally used for cephalosporins and may include an aryl group, a lower alkyl group, a lower-alkoxymethyl group, a lower-alkylthio methyl group and a lower-alkanoyloxymethyl group and the like. The group R^3 may also include a
20 metabolically unstable group which is easily hydrolyzed and cleaved in vivo and which may include, for example, a lower-alkoxycarbonyloxyalkyl group, a lower-alkyl-carbonyloxyalkyl group, an unsubstituted or substituted (2-oxo-1,3-dioxolene-4-yl) methyl group and the like.

25 "Unsubstituted or substituted phenyl group" which

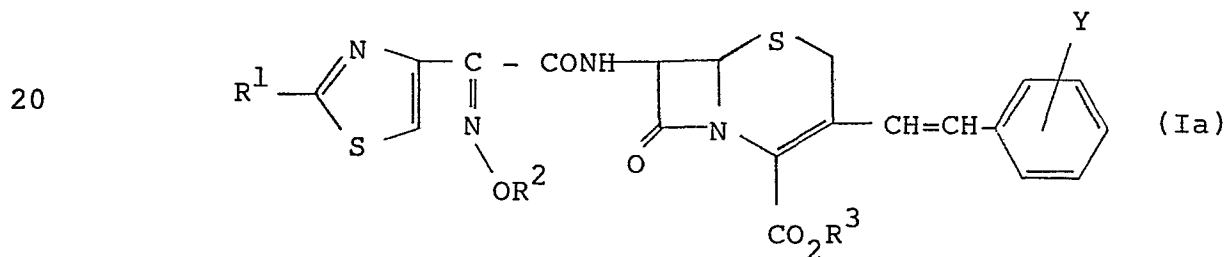
A represents includes a phenyl group; a phenyl group having a lower alkyl substituent, for example, p-tolyl; a halogenated phenyl group such as o-fluorophenyl, and a lower alkoxyphenyl group such as p-anisyl.

5 "Unsubstituted or substituted furyl group" which A represents includes a 2-furyl group, a 3-furyl group and a 5-nitro-2-furyl group.

"Unsubstituted or substituted thiazolyl group" which A represents includes thiazol-2-yl group, thiazol-4-yl group, thiazol-5-yl group, a 2-lower-alkylthiazol-5-yl group (e.g., 2-methylthiazol-5-yl), 4-methylthiazol-5-yl group, a 4-halo-thiazol-5-yl group and a 2,4-di-halo-thiazol-5-yl group.

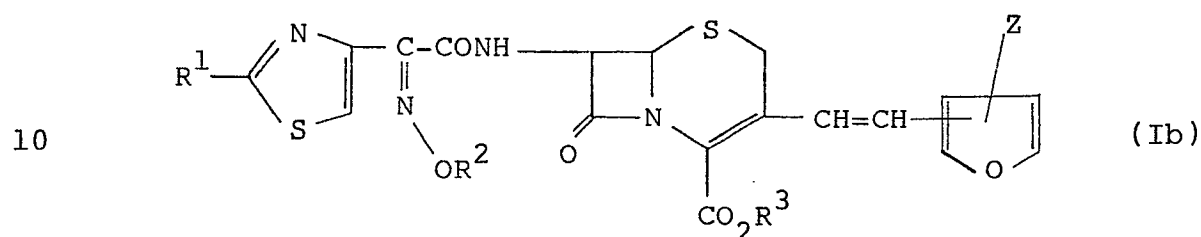
15 "Unsubstituted or substituted 3-lower-alkylthiazolio group" which A represents includes a 3,4-dimethyl-5-thiazolio group.

According to a preferred, first embodiment of the first aspect invention, there is provided a cephalosporin compound of the general formula (Ia)



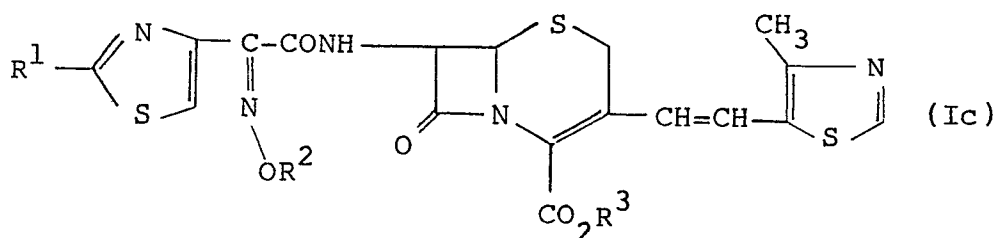
wherein R^1 is an amino group or a protected amino group,
 R^2 is a lower alkyl group, a carboxymethyl group or a
 protected carboxymethyl group, R^3 is a hydrogen atom, a
 salt-forming cation or a carboxyl-protecting group, and
 5 Y is a hydrogen atom, a lower alkyl group, a lower alkoxy
 group or a halogen atom.

According to a preferred, second embodiment of the
 first aspect invention, there is provided a cephalosporin
 compound of the general formula (Ib)



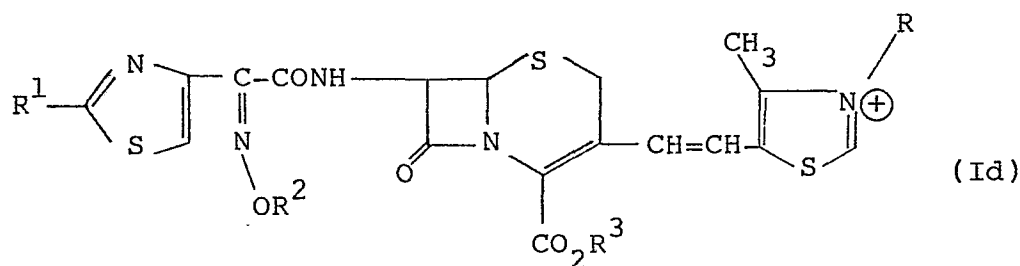
wherein R^1 is an amino group or a protected amino group,
 R^2 is a lower alkyl group, a carboxymethyl group or a
 protected carboxymethyl group, R^3 is a hydrogen atom, a
 salt-forming cation or a carboxyl-protecting group, Z is
 15 a hydrogen atom, nitro group or a halogen atom.

According to a preferred, third embodiment of the
 first aspect invention, there is provided a cephalosporin
 compound of the general formula (Ic)



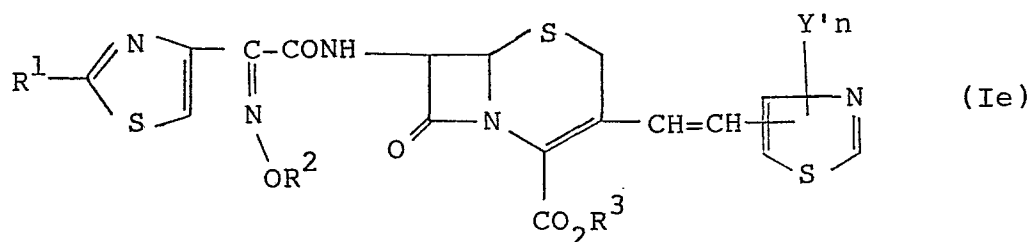
wherein R^1 is an amino group or a protected amino group,
 R^2 is a lower alkyl group, a carboxymethyl group or a
 protected carboxymethyl group, and R^3 is a hydrogen atom,
 a salt-forming cation or a carboxyl-protecting group.

5 According to a preferred, fourth embodiment of the
 first aspect invention, there is provided a cephalosporin
 compound of the general formula (Id)



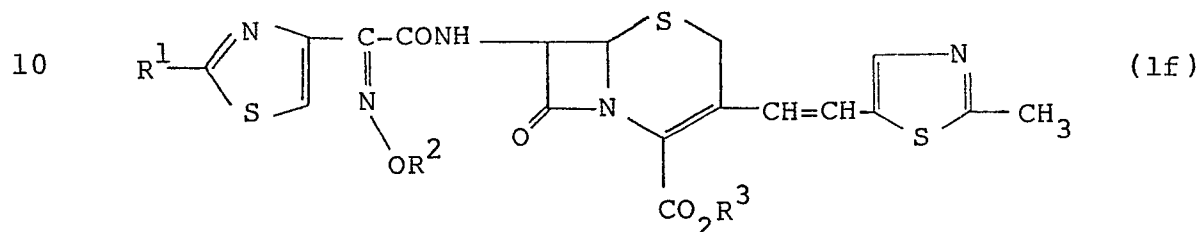
wherein R^1 is an amino group or a protected amino group,
 10 R^2 is a lower ($C_1 - C_6$) alkyl group, a carboxymethyl group
 or a protected carboxymethyl group, R^3 is a hydrogen atom,
 a salt-forming cation or a carboxyl-protecting group, and
 R is a lower alkyl group.

15 According to a preferred, fifth embodiment of the
 first aspect invention, there is provided a cephalosporin
 compound of the general formula (Ie)



wherein R^1 is an amino group or a protected amino group,
 R^2 is a lower ($C_1 - C_6$) alkyl group, a carboxymethyl group
 or a protected carboxymethyl group, R^3 is a hydrogen atom,
 a salt-forming cation or a carboxyl-protecting group, and
 5 Y' is a hydrogen atom or a halogen atom, and n is a whole
 number of 1 or 2.

According to a preferred, sixth embodiment of the
 first aspect invention, there is provided a cephalosporin
 compound of the general formula (If)



wherein R^1 is an amino group or a protected amino group,
 R^2 is a lower ($C_1 - C_6$) alkyl group, a carboxymethyl group
 or a protected carboxymethyl group, and R^3 is a hydrogen
 atom, a salt-forming cation or a carboxyl-protecting group.

15 Preferred examples of the new cephalosporin compound
 of the formula (I) or of the formula (Ia) to (If) according
 to this invention are listed below:

(A) 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)-
 acetamido]-3-(2-phenylvinyl)-3-cephem-4-carboxylic
 20 acid (syn-isomer, trans-isomer, or syn-isomer, cis-
 isomer).

- (B) 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-(2-phenylvinyl)-3-cephem-4-carboxylic acid (syn-
isomer, trans-isomer, or syn-isomer, cis-isomer).
- 5 (C) 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(o-fluorophenyl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer, trans-isomer, or syn-isomer, cis-
isomer).
- 10 (D) 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(2-o-fluorophenyl)vinyl]-3-cephem-
4-carboxylic acid (syn-isomer, trans-isomer, or syn-
isomer, cis-isomer).
- 15 (E) 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(2-furyl)vinyl]-3-cephem-4-
carboxylic acid (syn-isomer, trans-isomer, or syn-
isomer, cis-isomer).
- (F) 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(2-furyl)vinyl]-3-cephem-4-carboxylic acid
(syn-isomer, trans-isomer, or syn-isomer, cis-isomer).
- 20 (G) 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(5-nitro-2-furyl)vinyl]-3-cephem-
4-carboxylic acid (syn-isomer, trans-isomer, or syn-
isomer, cis-isomer).
- 25 (H) 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(5-nitro-2-furyl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer, trans-isomer, or syn-isomer, cis-
isomer).

- (I) 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(thiazol-2-yl)vinyl]-3-cephem-4-carboxylic acid
(syn-isomer, trans-isomer, or syn-isomer, cis-isomer).
- 5 (J) 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(thiazol-4-yl)vinyl]-3-cephem-4-carboxylic acid
(syn-isomer, trans-isomer, or syn-isomer, cis-isomer).
- (K) 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(thiazol-5-yl)vinyl]-3-cephem-4-
10 carboxylic acid (syn-isomer, trans-isomer, or syn-
isomer, cis-isomer).
- (L) 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(thiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid
(syn-isomer, trans-isomer, or cyn-isomer, cis-isomer).
- 15 (M) 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-
cephem-4-carboxylic acid (syn-isomer, trans-isomer,
or cyn-isomer, cis-isomer).
- 20 (N) 7-[2-t-butoxycarbonylmethoxyimino-2-(2-tritylamino-
thiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)
vinyl]-3-cephem-4-carboxylic acid (syn-isomer, trans-
isomer, or syn-isomer, cis-isomer).
- 25 (O) 7-[2-carboxymethoxyimino-2-(2-aminothiazol-4-yl)
acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-
cephem-4-carboxylic acid (syn-isomer, trans-isomer,
or syn-isomer, cis-isomer).

- (P) 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic
acid (cyn-isomer, trans-isomer, or cyn-isomer, cis-
isomer).
- 5 (Q) 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(2-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer, trans-isomer, or syn-isomer, cis-
isomer).
- (R) 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)
10 acetamido]-3-[2-(2-methylthiazol-5-yl)vinyl]-3-
cephem-4-carboxylic acid (syn-isomer, trans-isomer,
or syn-isomer, cis-isomer).
- (S) 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(4-chlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylic
15 acid (syn-isomer, trans-isomer, or cyn-isomer, cis-
isomer).
- (T) 7-[2-methoxyimino-2-(2-amino-thiazol-4-yl)
acetamido]-3-[2-(2,4-dichlorothiazol-5-yl)vinyl]-
3-cephem-4-carboxylic acid (syn-isomer, trans-isomer,
20 or syn-isomer, cis-isomer).
- (U) 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(3,4-dimethyl-5-thiazolio)vinyl]-
3-cephem-4-carboxylic acid (syn-isomer, trans-
isomer, or syn-isomer, cis-isomer) iodide or tri-
25 fluoroacetate.

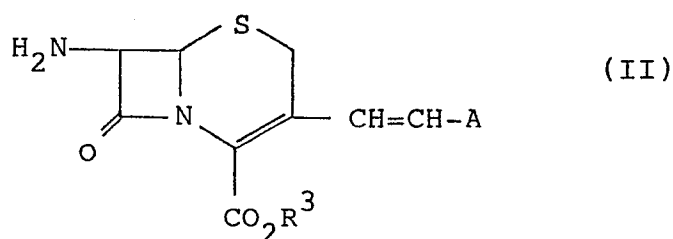
(V) 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(3,4-dimethyl-5-thiazolio)vinyl]-3-cephem-4-
carboxylic acid (syn-isomer, trans-isomer, or syn-
isomer, cis-isomer) iodide or trifluoroacetate.

5 Each of the particular cephalosporin compounds as
listed above may also be in the form of its carboxylate
(at the carboxyl group at the 2-position of the cephem
nucleus), for example, its sodium salt, its methyl ester,
its ethyl ester, its diphenylmethyl ester, its p-methoxy-
10 benzyl ester, its pivaloyloxymethyl ester and its (5-methyl-
2-oxo-1,3-dioxolene-4-yl)methyl ester.

The new compound of the formula (I) according to this
invention may be prepared by any one of the following two methods.

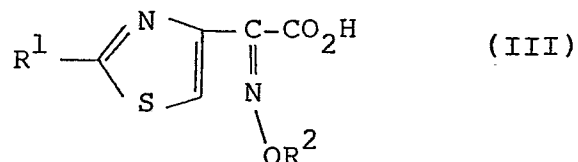
Method 1:

15 In this Method 1, a 7-aminocephalosporanic acid
compound of the formula (II)



wherein R^3 and A are as defined above, or a reactive
derivative (such a derivative made reactive at the 7-amino
20 group as shown in the formula) of the compound of the
formula (II) or a salt thereof is reacted with a 2-(2-
aminothiazol-4-yl)-2-alkoxyiminoacetic acid compound of

the formula (III)



wherein R¹ and R² are as defined above, or a reactive acid derivative (such a derivative made reactive at the carboxyl group as shown in the formula) of the compound of the formula (III) or a salt thereof.

Examples of the reactive derivative at the amino group of the compound (II) include such an imino derivative of Schiff-base type which may be obtained by reaction of the compound (II) with a carbonyl compound such as an aldehyde or ketone, or an enamine-type isomer (tautomer) of said imino derivative; such a silyl derivative which may be obtained by reaction of the compound (II) with a silyl compound such as bis-(trimethylsilyl)acetamide; or such a derivative which may be obtained by reaction of the compound (II) with phosphorus trichloride or phosgene.

Appropriate examples of the salts of the compound (II) or (III) include an acid-addition salt thereof, for example, a salt of the compound (II) or (III) with an organic acid such as acetic acid, maleic acid, tartaric acid, benzenesulfonic acid, toluenesulfonic acid; a salt

of the compound (II) or (III) with an inorganic acid such as hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid; a metal salt (carboxylate) of the compound (II) or (III) with an alkali metal such as sodium and potassium or with an alkaline earth metal such as calcium and magnesium; ammonium salt (carboxylate) of the compound (II) or (III); an amine salt of the compound (II) or (III) with an organic amine such as triethylamine and dicyclohexylamine.

Suitable examples of the reactive derivative at the carboxyl group of the compound (III) include an acid halide, an acid azide, an acid anhydride, an activated amide and an activated ester of the compound (III), and especially they may be an acid chloride or an acid bromide of the compound (III); a mixed acid anhydride of the compound (III) with an acid, for example, with a substituted phosphoric acid such as dialkylphosphoric acid, phenylphosphoric acid, diphenylphosphoric acid, dibenzylphosphoric acid, a halogenated phosphoric acid, with a dialkyl phosphoric acid, with sulfurous acid, with thio-sulfuric acid, with sulfuric acid, with an alkyl carbonate such as methyl carbonate and ethyl carbonate, with an aliphatic carboxylic acid such as pivalic acid, valeric acid, isovaleric acid, 2-ethylacetic acid and trichloroacetic acid, or with an aromatic carboxylic acid such as benzoic acid; a symmetrical acid anhydride of the compound (III); an activated

amide of the compound (III) formed with imidazole, 4-substituted imidazole, dimethylpyrazole, triazole or tetrazole; an activated ester of the compound (III) such as cyanomethyl ester, methoxymethyl ester, dimethylimino-
5 methyl ester, vinyl ester, propargyl ester, p-nitrophenyl ester, 2,4-dinitrophenyl ester, trichlorophenyl ester, pentachlorophenyl ester, mesylphenyl ester, phenylazo-phenyl ester, phenylthio ester, p-nitrophenylthio ester, p-cresylthio ester, carboxymethylthio ester, pyranyl ester,
10 pyridyl ester, piperidyl ester or 8-quinolylthio ester; or an ester of the compound (III) formed with a N-hydroxyl compound such as N,N-dimethylhydroxylamine, 1-hydroxy-2-(1H)-pyridone, N-hydroxysuccinimide, N-hydroxyphthalimide or 1-hydroxy-6-chloro-1H-benzotriazole.

15 These reactive derivatives of the compound (II) may be properly selected depending on the nature of the compound (III) to be reacted therewith.

 The reaction of condensing the compound (II) with the compound (III) may usually be conducted in a conventional
20 unreactive solvent such as water, acetone, dioxane, acetonitrile, chloroform, methylene chloride, ethylene chloride, tetrahydrofuran, ethyl acetate, N,N-dimethylformamide, pyridine, or in any other solvent which exerts no adverse effect on the progress of this reaction. These solvents
25 may be used as a mixture with water.

In the case where the compound (III) is used in the form of a free acid or in the form of a salt, the reaction may preferably be conducted in the presence of a condensing agent. Examples of such a condensing agent may be N,N'-
5 dicyclohexylcarbodiimide; N-cyclohexyl-N'-morpholino-ethylcarbodiimide; N-cyclohexyl-N'-(4-diethylamino-cyclohexyl)carbodiimide; N,N'-diethylcarbodiimide; N,N'-diisopropylcarbodiimide; N-ethyl-N'-(3-dimethylaminopropyl)carbodiimide; N,N'-carbonyl-bis(2-methylimidazole); penta-
10 methyleneketene-N-cyclohexylimine; diphenylketene-N-cyclohexylimine; ethoxyacetylene; 1-alkoxy-1-chloroethylene; phosphorous acid trialkylester; ethyl polyphosphate; isopropyl polyphosphate; phosphorus oxychloride; phosphorus trichloride; thionyl chloride; oxalyl chloride; triphenyl-
15 phosphine; 2-ethyl-7-hydroxybenzoxazolium salt; 2-ethyl-5-(m-sulfophenyl)isoxazolium hydroxide (intramolecular salt); 1-(p-chlorobenzenesulfonyloxy)-6-chloro-1H-benzotriazole; Vilsmeier reagent as prepared from reaction of dimethylformamide with thionyl chloride, phosgene and phosphorus
20 oxychloride.

This reaction according to Method 1 may also be conducted in the presence of an inorganic or organic base. Examples of these inorganic and organic bases may be an alkali metal hydrogen carbonate such as sodium hydrogen
25 carbonate or potassium hydrogen carbonate, an alkali metal

carbonate such as sodium carbonate or potassium carbonate,
an alkaline earth metal carbonate such as calcium carbo-
nate, a tri-(lower)alkyl amine such as trimethylamine or
triethylamine, pyridine, N-(lower)alkylmorpholine, N,N-di-
5 (lower)alkylbenzylamine.

The reaction as above may be carried out at a non-
critical temperature, and may usually be conducted under
cooling or under heating.

The product compound of the formula (I) which has
10 been prepared by the above reactions for the preparation
thereof, if desired, may then be subjected to further con-
ventional step(s) for removal of the remaining carboxyl-
protecting group and/or the remaining amino-protecting
group therefrom, and/or to further conventional step(s)
15 for converting the carboxyl group(s) of the product compound
(I) into a metabolically unstable, non-toxic ester (carbo-
xylate) group. The method for removal of the carboxyl-
protecting group and/or the amino-protecting group may
properly be chosen according to the nature of the pro-
20 tecting groups to be removed.

The amino-protecting group may be removed from the
product compound (I) by a conventional deprotecting
technique, for example, by hydrolysis or reduction, and
for such a product compound bearing an acyl group as the
25 amino-protecting group to be removed, it is feasible to

subject such product compound (I) to a reaction with an imino-halogenating agent and then with an imino-etherifying agent, if necessary, followed by hydrolysis. Acid hydrolysis is one of the conventional methods for removing the amino-protecting groups and is applicable to the removal of such groups as an alkoxycarbonyl group, formyl group and triflyl group. The acids available for this acid hydrolysis may be formic acid, trifluoroacetic acid, p-toluenesulfonic acid, hydrochloric acid and other organic or inorganic acids, and preferably the acids are formic acid, trifluoroacetic acid and hydrochloric acid which afford easy after-treatment of the reaction mixture. These acids for hydrolysis are selected properly according to the nature of the amino-protecting group to be removed. This hydrolysis reaction may be carried out either in the absence of any solvent or in the presence of a solvent such as water, a hydrophilic organic solvent or a mixture of organic solvents. When trifluoroacetic acid is employed for the acid hydrolysis, the reaction may suitably be conducted in the presence of anisole.

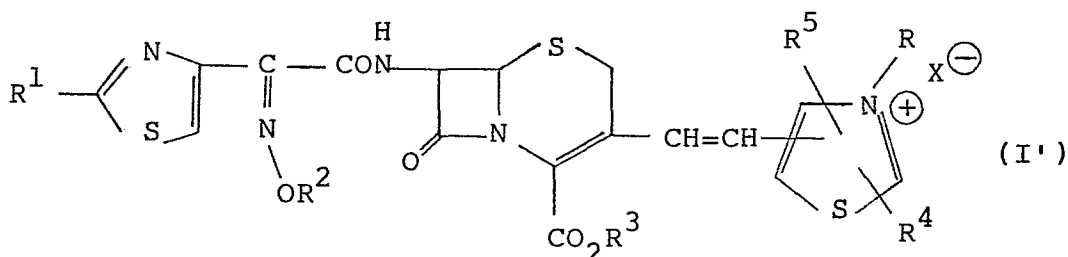
The carboxyl-protecting group may be removed also in a conventional manner, for example, by hydrolysis or reduction. Acid hydrolysis is one of the conventional deprotection methods which is advantageously applicable to the removal of the carboxyl-protecting group of such

kind as silyl group and diphenylmethyl group.

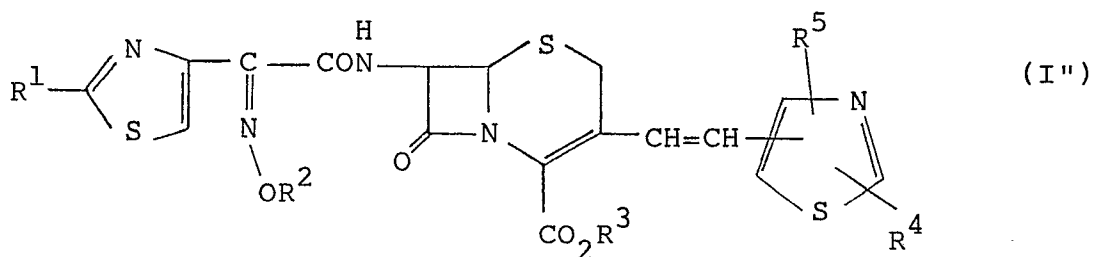
The conversion of the carboxyl group into the metabolically unstable ester group may be performed by a conventional method comprising reacting a metal salt of the corresponding carboxylic acid compound with an alkyl halide such as a pivaloyloxymethyl halide e.g. chloride in an organic solvent.

Method 2:

According to this Method 2, such a cephalosporin compound of the formula (I) where the group A denotes a 3-lower-alkylthiazolyl group, that is, such a compound of the following formula (I'):



wherein R^1 , R^2 and R^3 are as defined above, R is a lower alkyl group, and R^4 and R^5 are the same or different and each are a hydrogen atom, a lower alkyl group or a halogen atom such as chlorine atom (which may be prepared by the procedure of the Method 1 above) is produced by the method comprising reacting a compound of the formula (I'')



wherein R^1 , R^2 , R^3 , R^4 and R^5 are as defined above, with an alkylating agent selected from an alkyl halide of the formula RX wherein R is a lower alkyl group such as methyl and ethyl and X is a halogen atom such as chlorine, bromine or iodine atom; a mono- or di-lower-alkyl sulfate; and a lower alkyl lower-alkanesulfonate, to alkylate the 3-nitrogen atom of the thiazolyl group of the compound of the formula (I''). The alkyl halide of the formula RX as the alkylation agent may be methyl bromide, methyl iodide, ethyl bromide and ethyl iodide, for example. The mono- or di-lower-alkyl sulfate as the alkylation agent may be mono-methyl or di-methyl sulfate and mono-ethyl or di-ethyl sulfate. The lower alkyl lower-alkanesulfonate may be methyl methanesulfonate, for example. The reaction of alkylating the 3-nitrogen atom of the thiazolyl group of the compound (I'') may be achieved in a conventional manner known for alkylation of the organic nitrogen atom. When the alkylation reaction is conducted using a lower alkyl ester of the sulfuric or sulfonic acid as the alkylating

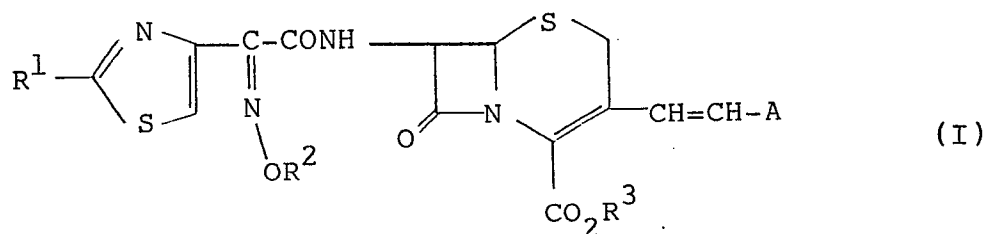
agent (RX), this reaction may normally be conducted in a solvent such as benzene, toluene, dichloroethane, dichloromethane, chloroform, water, acetone, tetrahydrofurane, ethanol, ethyl ether, dimethylformamide or in any other
5 solvent which exerts no adverse effect on the progress of this reaction.

This reaction according to Method 2 may also preferably be conducted in the presence of such an inorganic or organic base as described in Method 1. The alkylation
10 reaction as above may be carried out at any temperature which is not limited critically, and the alkylation may usually be conducted at a temperature of up to the boiling point of the solvent used in this reaction, under cooling or heating.

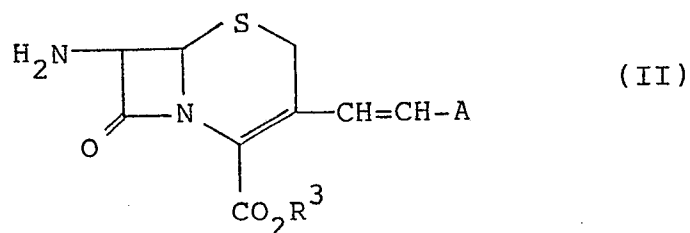
15 The product compound (I') which has been prepared by the above alkylation reaction may, if desired, then be subjected to further conventional step(s) for removing the remaining carboxyl-protecting group and/or the remaining amino-protecting group therefrom, and/or to further con-
20 vention step(s) for converting the carboxyl group(s) of the product compound (I') into a metabolically unstable, non-toxic ester (carboxylate) group, in the same manner as described for the procedures of Method 1.

According to a second aspect of this invention,
25 therefore, there is provided a process for the production

of a cephalosporin compound of the general formula (I)

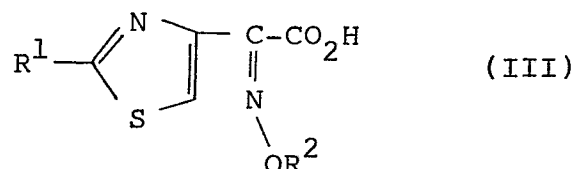


wherein R^1 is an amino group or a protected amino group,
 R^2 is a lower alkyl group, a carboxymethyl group or a
 5 protected carboxymethyl group, R^3 is a hydrogen atom, a
 salt-forming cation or a carboxyl-protecting group, and A
 is an unsubstituted or substituted phenyl group, an un-
 substituted or substituted furyl group or an unsubstituted
 or substituted thiazolyl group or an unsubstituted or
 10 substituted 3-lower-alkylthiazolio group, characterized in
 that the process comprises reacting a 7-aminocephalosporanic
 acid compound of the general formula (II)

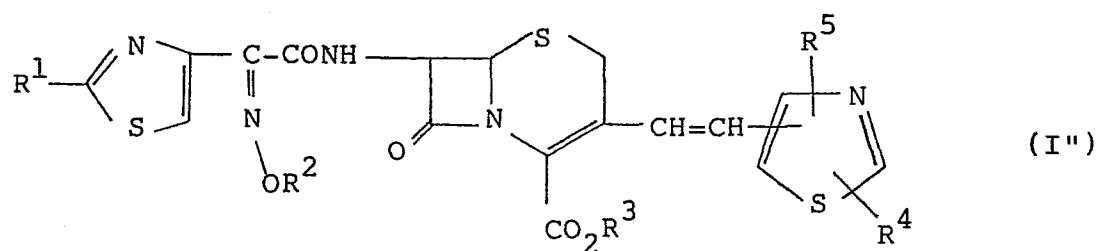


wherein R^3 and A are as defined above, or a functional
 15 equivalent thereof (including a reactive derivative at the
 amino group of the compound of the formula (II) and a salt

of the compound of the formula (II)), with a 2-(2-amino-thiazol-4-yl)-2-alkoxyimino-acetic acid compound of the formula (III)

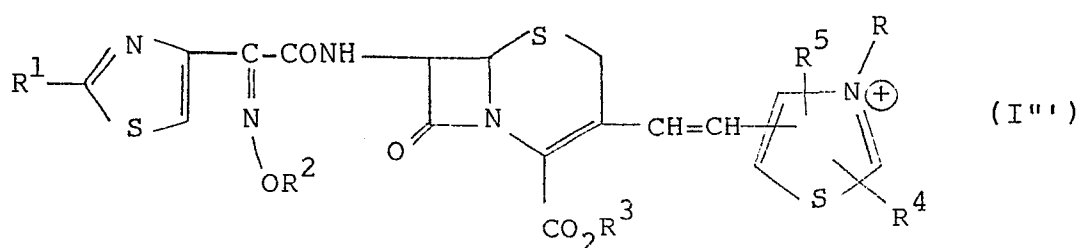


5 wherein R^1 and R^2 are as defined above, or a functional equivalent thereof (including a reactive acid derivative of the compound of the formula (III)) in an unreactive solvent at a temperature of not higher than the boiling temperature of the solvent used, to produce the compound
10 of the formula (I), and then, if desired, where the product compound of the formula (I) as produced is such one as shown by the formula (I'')



15 wherein R^1 , R^2 and R^3 are as defined above, and R^4 and R^5 are the same or different and each are a hydrogen atom, a lower alkyl group or a halogen atom such as a chlorine

atom, alkylating the 3-nitrogen atom of the thiazolyl group of the compound of the formula (I'') by reacting with an alkyl halide of the formula RX wherein R is a lower alkyl group and X is a halogen atom, such as chlorine or bromine atom, or a mono- or di-lower-alkyl sulfate or a lower alkyl lower-alkanesulfonate, to produce the compound of the formula (I''')



wherein R^1 , R^2 , R^3 , R^4 and R^5 are as defined above and R is corresponding to the lower alkyl group of the alkyl halide or the mono- or di-lower-alkyl sulfate or the lower alkyl lower-alkanesulfonate employed, and further, if desired, removing the remaining amino-protecting group and the remaining carboxyl-protecting group from the product compound of the formula (I) or of the formula (I''').

The process of the second aspect of this invention may include a further step of reacting the compound of the formula (I) where R^3 is a hydrogen atom, with an alkali metal hydroxide, an alkali metal hydrogen carbonate or an alkali metal carbonate or an alcohol such as a lower alkanol

to produce the compound of the formula (I) where R^3 is an alkali metal cation or an ester-forming group such as a lower alkyl group. This reaction may be carried out in a known manner for the conversion of a carboxylic acid
5 into a corresponding alkali metal carboxylate or an ester of the carboxylic acid. In this way, the compound of the formula (I) in the form of a free carboxylic acid may be converted into the form of an alkali metal carboxylate or a carboxylic acid ester.

10 Examples of the pharmaceutically acceptable salts of the compound of the formula (I) include ordinary non-toxic salts, for example, salts (carboxylate) with an alkali metal such as sodium and potassium; salts with an alkaline earth metal such as calcium and magnesium;
15 ammonium salt; acid addition salts of the compound (I) with an organic base such as trimethylamine, triethylamine, pyridine, picoline, dicyclohexylamine, N,N'-dibenzylethylenediamine; acid-addition salts of the compound (I) with an organic acid such as acetic acid, trifluoroacetic acid,
20 maleic acid, tartaric acid, methanesulfonic acid, benzenesulfonic acid, formic acid and toluenesulfonic acid; acid-addition salts with an inorganic acid such as hydrochloric acid, hydrobromic acid, sulfuric acid and phosphoric acid;
25 arginic acid, aspartic acid and glutamic acid.

Examples of the pharmaceutically acceptable ester of the compound of the formula (I) according to this invention include the esters which are obtained by the esterification of the 2-carboxyl group of the compound of the formula (I) with a lower alkanoyloxymethyl group such as pivaloyloxymethyl group, a lower alkylcarbonyloxyalkyl group, a lower alkoxycarbonyloxyalkyl group, or a (2-oxo-1,3-dioxolene-4-yl)methyl group and the like.

The compounds of this invention are all novel compounds. Minimum inhibitory concentrations (MIC., $\mu\text{g/ml}$) of some of the new compounds against growth of bacteria as determined by agar-dilution method are shown in Table 1 below. As be apparent from Table 1, all the compounds under test of this invention exhibit high antibacterial activity and a wide range of antibacterial spectra, indicating that the new compounds of this invention are useful as antibacterial agent.

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Table 1

Test Organisms	MIC. ($\mu\text{g}/\text{m}\ell$)																
	Example No., 10 Compound	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"
Staphylococcus aureus 209P JC-1	0.20	0.78	0.39	6.25	0.20	0.78	3.13	0.39	0.10	0.78	0.78	0.39	0.39	0.39	0.39	0.20	0.20
Staphylococcus aureus Smith	0.39	0.78	0.78	6.25	0.39	0.78	3.13	0.39	0.20	1.56	1.56	0.78	0.39	0.39	0.39	0.20	0.20
Escherichia coli NIHJ JC-2	0.39	3.13	3.13	6.25	3.13	0.10	0.39	0.78	0.20	0.78	1.56	1.56	0.39	0.39	0.39	3.13	3.13
Klebsiella pneumoniae PCI 602	0.39	3.13	1.56	3.13	3.13	0.10	0.20	0.39	0.10	0.78	1.56	1.56	0.20	0.20	0.20	3.13	3.13
Proteus mirabilis GN 79	0.39	0.78	0.78	12.5	0.20	0.78	0.05	-	0.20	0.20	0.78	-	0.39	0.39	0.78	0.78	0.78
Proteus vulgaris GN 76	0.20	0.78	0.39	3.13	0.20	0.39	≤ 0.025	0.10	0.10	0.10	0.20	0.10	0.10	0.10	0.10	1.56	1.56
Proteus rettgeri GN 624	3.13	3.13	3.13	3.13	1.56	0.39	1.56	0.39	1.56	0.20	0.78	6.25	0.78	0.78	0.78	1.56	1.56
Salmonella typhimurium LT-2	0.39	6.25	1.56	6.25	3.13	0.10	0.10	0.78	0.20	0.39	1.56	0.78	0.39	0.39	0.39	3.13	3.13
Serratia marcescens No. 1	0.39	1.56	1.56	6.25	1.56	0.10	0.05	0.39	0.20	0.20	0.78	0.78	0.39	0.39	0.39	1.56	1.56
Pseudomonas aeruginosa MB 3833	25	>50	>50	>50	>50	>50	12.5	50	12.5	>50	>50	100	>50	100	25	100	100

Referring to Table 1 above, the Compounds of Examples under test are identified as follows:-

Example No. 10 Compound:

5. 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic
acid trifluoroacetate (cyn-isomer, cis-isomer)

Example No. 11 Compound:

10 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-(2-phenylvinyl)-3-cephem-4-carboxylic acid
trifluoroacetate (cyn-isomer, cis-isomer)

Example No. 12 Compound:

15 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(2-furyl)vinyl]-3-cephem-4-carboxylic acid
sodium salt (cyn-isomer, cis-isomer).

15 Example No. 13 Compound:

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(5-nitro-2-furyl)vinyl]-3-cephem-4-carboxylic
acid sodium salt (syn-isomer, trans-isomer).

Example No. 14 Compound:

20 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(o-fluorophenyl)vinyl]-3-cephem-4-carboxylic acid
trifluoroacetate (syn-isomer, mixed cis- and trans-isomers).

Example No. 15 Compound:

25 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(3,4-dimethyl-5-thiazolio)vinyl]-3-cephem-4-

carboxylic acid di-trifluoroacetate (syn-isomer).

Example No. 16 Compound:

7-[2-carboxymethoxyimino-2-(2-aminothiazol-4-yl)
acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-
5 4-carboxylic acid trifluoroacetate (syn-isomer, trans-isomer).

Example No. 18 Compound:

7-[2-methoxyimino-2-(2-aminothiazol-4-yl) acetamido]-
3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-
carboxylic acid sodium salt (syn-isomer, trans-isomer).

10 Example No. 21 Compound:

7-[2-methoxyimino-2-(2-aminothiazol-4-yl) acetamido]-
3-[2-(4-chlorothiazol-5-yl)vinyl]-3-cephem-4-
carboxylic acid sodium salt (syn-isomer, cis-isomer).

Example No. 30 Compound:

15 7-[2-methoxyimino-2-(2-aminothiazol-4-yl) acetamido]-
3-[2-(2-methylthiazol-5-yl)vinyl]-3-cephem-4-
carboxylic acid trifluoroacetate (syn-isomer, trans-
isomer).

Example No. 31 Compound:

20 7-[2-methoxyimino-2-(2-aminothiazol-4-yl) acetamido]-
3-[2-(2-methylthiazol-5-yl)vinyl]-3-cephem-4-
carboxylic acid trifluoroacetate (syn-isomer, cis-
isomer).

Example No. 32 Compound:

25 7-[2-methoxyimino-2-(2-aminothiazol-4-yl) acetamido]-

3-[2-(thiazol-4-yl)vinyl]-3-cephem-4-carboxylic acid
sodium salt (syn-isomer, cis-isomer).

Example No. 33 Compound:

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(thiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid
sodium salt (syn-isomer, cis-isomer).

Example No. 34 Compound:

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(2,4-dichlorothiazol-5-yl)vinyl]-3-cephem-4-
carboxylic acid sodium salt (syn-isomer, cis-isomer).

The new compound of the formula (I) or the formula
(Ia) to (If) according to this invention, or a pharmaceuti-
cally acceptable salt or ester thereof may be formulated
into a pharmaceutical composition by mixing with a pharma-
ceutically acceptable solid or liquid carrier or vehicle
when it is to be administered to man for the therapeutic
treatment of bacterial infections.

According to a further aspect of this invention,
therefore, there is provided a pharmaceutical, antibacterial
composition which comprises an antibacterially effective
amount of the compound of the formula (I) or of the formula
(Ia) to (If) as defined hereinbefore or a pharmaceutically
acceptable salt or ester thereof as the active ingredient,
in combination of a pharmaceutically acceptable carrier for
the active ingredient.

The pharmaceutically acceptable carrier as mixed with the active ingredient compound may be an ordinary solid or liquid one, either organic or inorganic, which may be chosen appropriately depending on whether the pharmaceutical formulation as prepared is to be administered orally or non-orally or applied externally. The pharmaceutical composition of this invention may be of any conventional formulation form such as capsules, tablets, sugar-coated pills, ointment, suppository, solution, suspension and emulsion. Other conventional additives, including adjuvant, stabilizing agent, wetting agent, emulsifying agent, buffer solution may also be incorporated into the pharmaceutical composition of this invention containing the compound (I) as the active ingredient.

The new cephalosporin compound of this invention as orally administered is easily absorbed through the intestines by a living animal and maintains its antibacterial activity to a substantial extent in the body of the animal until it is excreted in the urine of the animal, and this may be observed by determining the remaining amount of the cephalosporin compound of this invention which can be recovered in the urine without receiving a substantial degradation of the compound in vivo. Some tests were made to evaluate the amount of the cephalosporin compound of this invention which can be recovered as the antibacterially

active compound from the urine after it was orally given to mice.

Test 1

To mice of ICR-strain (male, 4-weeks-aged, three in each group) was orally administered the compound under test identified below, at a dosage of the compound of 0.5 mg per mouse. The compound under test was given as a suspension of the test compound in a solution of 0.2% carboxymethyl-cellulose (CMC) in water. By the end of 4 hours after the administration of the test compound, all the amounts of the urine excreted by the treated mice were collected together, and the total quantity of the cephalosporin compound of this invention (as the free carboxylic acid form) in the urine was determined according to a paper-disc assay method using Escherichia coli K-12 8236 as the assaying strain.

The compound under test was the Example No. 22 Compound, namely 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(4-chlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, cis-isomer) pivaloyloxymethyl ester; and the Example No. 38 Compound, namely 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetoamido]-3-[2-(thiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, cis-isomer) pivaloyloxymethyl ester.

Rate of recovery of the cephalosporin compound in urine was calculated in term of percentages of the molar quantity of

the cephalosporin compound as recovered (as the free carboxylic acid form) based on the molar quantity of the cephalosporin compound as orally given.

The test results obtained (as averaged for three mice) are shown in Table 2 below.

Table 2

<u>Test compound</u>	<u>Rate of recovery of the test compound in urine (%)</u>
Example No. 22 Compound	24
Example No. 38 Compound	20

In the above tests, the cephalosporin compounds under test as orally given each were converted in vivo into the corresponding free carboxylic acid form owing to easy cleavage of the ester-forming pivaloyloxymethyl group from the 4-carboxyl group of the compound after they were absorbed in the animal body. The test compounds were excreted in the urine in the form of its free carboxylic acid, of which the antibacterial potency was evaluated by the bio-assay method.

This invention is now illustrated with reference to the following Examples. Examples 1-39 illustrate the procedures for preparing the new cephalosporin compounds of this invention, and Reference Examples 1-8 illustrate the procedures for preparing the starting compounds employed for the preparation of the new compounds of this invention.

Reference Example 1

Production of 7-(phenoxyacetamido)-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid benzhydryl ester

(1) Benzhydryl 7-(phenoxyacetamido)-3-(triphenylphosphoran -diylmethyl)-3-cephem-4-carboxylate (1.55 g) and 4-methylthiazol-5-carboaldehyde (0.305 g) were dissolved in methylene chloride (20 ml), to which aqueous saturated sodium bicarbonate (20 ml) was added at ambient temperature. The resultant mixture was stirred for 17 hours at ambient temperature. The mixture was allowed to stand until it separated into the aqueous phase and organic solvent phase. The aqueous phase was removed and washed with methylene chloride (20 ml), and the washings (in methylene chloride) were combined with the organic solvent phase separated. The combined solution was dried over anhydrous magnesium sulfate and then concentrated to dryness under reduced pressure. The solid residue obtained was purified chromatographically on a column of silica gel (Wako gel C-300) (40 g)

as developed with benzene-ethyl acetate (5:1) as the development solvent. The titled compound, 7-(phenoxyacetamido)-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid benzhydryl ester (0.741 g) was obtained.

5 NMR, δ (CDCl₃) : 2.34 (3H, s), 3.24 (1H, d, J=18 Hz), 3.48 (1H, d, J=18 Hz), 4.55 (2H, s), 5.12 (1H, d, J=5 Hz), 5.95 (1H, dd, J=5 Hz, 9 Hz), 6.25 (1H, d, J=12 Hz), 6.49 (1H, d, J=12 Hz), 6.8-7.5 (16H, m), 8.56 (1H, s).

(2) Benzhydryl 7-(phenoxyacetamido)-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylate (0.725 g) was dissolved in anisole (2 ml), to which trifluoroacetic acid (7 ml) was added under ice-cooling. The mixture was stirred for 1 hour under ice-cooling. The reaction mixture was concentrated under reduced pressure to give a syrup, which was then solidified by addition of isopropyl ether thereto. The solid obtained was pulverized and was mixed with isopropyl ether for the washing purpose, and the mixture was filtered to recover the solid which was then dried under reduced pressure. 7-(Phenoxyacetamido)-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (0.512 g) was thus obtained.

20 NMR, δ (CDCl₃) : 2.38 (3H, s), 3.19 (1H, d, J=18 Hz), 3.46 (1H, d, J=18 Hz), 4.55 (2H, s), 5.09 (1H, d, J=5 Hz), 5.91 (1H, d, J=5 Hz), 6.44 (1H, d, J=12 Hz), 6.57 (1H, d, J=12 Hz), 6.8-7.6 (6H, m), 8.79 (1H, s).

(3) 7-(Phenoxyacetamido)-3-[2-(4-methylthiazol-5-yl) vinyl]-3-cephem-4-carboxylic acid (0.490 g) was dissolved in ethyl acetate (5 ml), to which sodium 2-ethylhexanoate (0.300 g) was added. The resultant mixture was stirred for 30 minutes, and the precipitate as formed was removed from the mixture by filtration and washed with a mixture of ethyl acetate and isopropyl ether (1:1). The solid product (as the sodium salt) was dissolved in dimethylformamide (5 ml) under ice-cooling, to which was added such a solution in dimethylformamide (3 ml) of iodomethyl pivalate as prepared from chloromethyl pivalate (0.450 g) and sodium iodide (0.450 g). The resultant mixture was stirred for 1 hour under ice-cooling. To the reaction mixture was added ethyl acetate (50 ml), followed by washing the mixture three times with ice-water (each 30 ml). The organic solvent phase was separated out of the mixture, dried over anhydrous magnesium sulfate and then concentrated to dryness under reduced pressure. The solid residue obtained was purified chromatographically on a column of silica gel (Wako-gel C-300) (20 g) as developed with benzene-ethyl acetate (5:1) as the development solvent. 7-(Phenoxyacetamido)-3-[2-(4-methylthiazol-5-yl) vinyl]-3-cephem-4-carboxylic acid pivaloyloxymethyl ester (0.405 g) was thus obtained.

NMR, δ (CDCl₃) : 1.15 (9H, s), 2.45 (3H, s), 3.17 (1H, d, J=18 Hz), 3.50 (1H, d, J=18 Hz), 4.57 (2H, s),

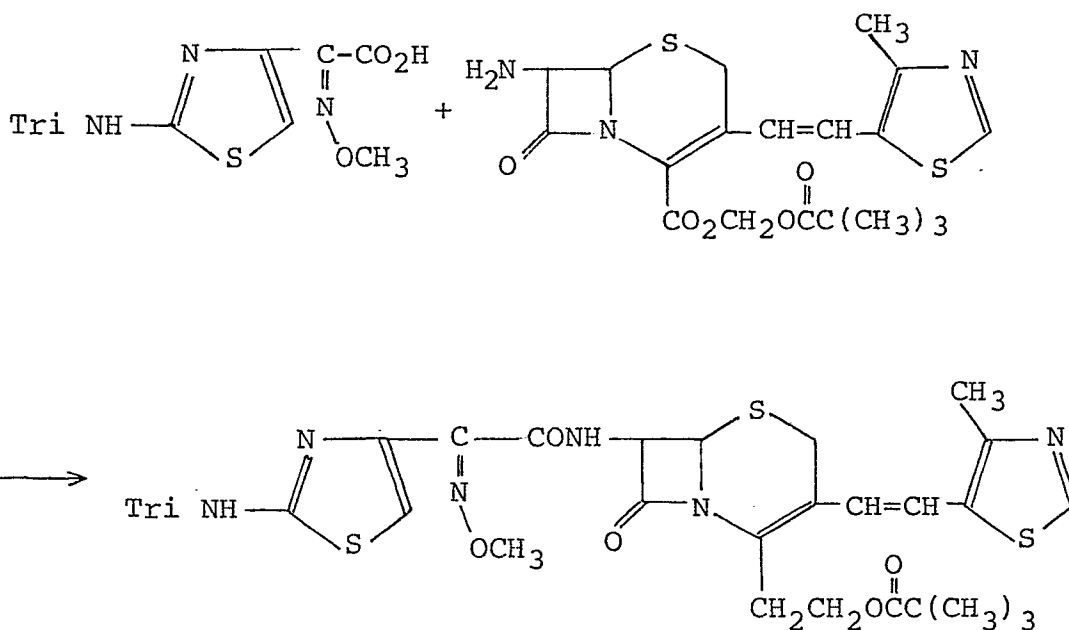
5.12 (1H, d, J=5 Hz), 5.77 (1H, d, J=5 Hz), 5.84 (1H, d, J=5 Hz), 5.95 (1H, dd, J=5 Hz, 9 Hz), 6.35 (1H, d, J=12 Hz), 6.64 (1H, d, J=12 Hz), 6.8-7.5 (6H, m), 8.62 (1H, s).

(4) 7-(Phenoxyacetamido)-3-[2-(4-methylthiazol-5-yl) vinyl]-3-cephem-4-carboxylic acid pivaloyloxymethyl ester (0.303 g) was dissolved in methylene chloride (3 ml). The solution obtained was poured into a solution (10 ml) containing phosphorus pentachloride (0.331 g) and pyridine (0.43 g) in methylene chloride at -30°C. The resultant solution was stirred for 3 hours under ice-cooling and was poured into methanol (20 ml) as cooled previously to -30°C, followed by stirring the mixture for further 30 minutes at ambient temperature. The reaction solution obtained was then poured into a mixture of aqueous saturated sodium chloride (50 ml) and methylene chloride (50 ml) under ice-cooling, followed by stirring for 1 hour under ice-cooling. The organic phase was separated from the aqueous phase, and the aqueous phase was extracted with methylene chloride (20 ml). The extract (in methylene chloride) was combined with said organic phase, and the resultant mixture was washed with aqueous saturated sodium bicarbonate solution. The washed organic phase was dried over anhydrous magnesium sulfate and concentrated under reduced pressure to a volume of 5 ml. 7-Amino-3-[2-(4-methylthiazol-5-yl) vinyl]-3-cephem-4-carboxylic acid pivaloyloxymethyl ester was thus obtained

as its solution in methylene chloride.

Example 1

Production of 7-[2-methoxyimino-2-(2-tritylamino-
thiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]
-3-cephem-4-carboxylic acid (syn-isomer) pivaloyloxymethyl
ester



(Tri denotes trityl group.)

7-Amino-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-
4-carboxylic acid pivaloyloxymethyl ester (0.229 g) as
prepared in Reference Example 1 as above was dissolved in
methylene chloride (5 ml). The resultant solution was
admixed with 2-(2-tritylaminothiazol-4-yl)-2-methoxyimino-
acetic acid (syn-isomer) (0.235 g) and methylene chloride

(5 ml). To the mixture obtained were further added pyridine (0.07 ml) and then dropwise phosphorus oxychloride (0.07 ml) at -20°C. The reaction mixture was stirred for 10 minutes at 0°C and poured into a mixture of ice-water (50 ml) and ethyl acetate (50 ml). After stirring, the organic phase was separated from the aqueous phase and washed with ice-water and then with ice-cooled aqueous saturated sodium hydrogen carbonate solution. The organic phase was dried over anhydrous magnesium sulfate and concentrated under reduced pressure. The residue was purified chromatographically on a column of silica gel (Wako gel C-300) (20 g) as developed with benzene-ethyl acetate (5:1) as the development solvent. 7-[2-Methoxyimino-2-(2-tritylaminothiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer) pivaloyloxymethyl ester (0.184 g) was obtained.

NMR, δ (CDCl₃) : 1.13 (9H, s), 2.43 (3H, s), 3.26 (1H, d, J=18 Hz), 3.57 (1H, d, J=18 Hz), 4.04 (3H, s), 5.13 (1H, d, J=5 Hz), 5.76 (1H, d, J=5 Hz), 5.82 (1H, d, J=5 Hz), 5.95 (1H, dd, J=5 Hz, 9 Hz), 6.34 (1H, d, J=12 Hz), 6.64 (1H, d, J=12 Hz), 6.70 (1H, s), 6.90 (1H, d, J=9 Hz), 7.00 (1H, broad s), 7.1-7.5 (25H, m), 8.59 (1H, s).

Example 2

Production of 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-

4-carboxylic acid (syn-isomer) pivaloyloxymethyl ester.

7-[2-Methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-
4-carboxylic acid (syn-isomer) pivaloyloxymethyl ester
5 (0.160 g) was dissolved in anisole (0.5 ml). The resultant
solution was admixed with trifluoroacetic acid (1.5 ml)
under ice-cooling, followed by stirring for 30 minutes
again under ice-cooling. The reaction solution was mixed
with isopropyl ether (30 ml), and the powder substance
10 deposited was recovered by filtration and washed with
isopropyl ether. The solid obtained was dissolved in ethyl
acetate (20 ml), washed with ice-cooled aqueous saturated
sodium hydrogen carbonate solution (10 ml). The organic
phase was separated from the aqueous phase, dried over
15 anhydrous sodium sulfate and concentrated under reduced
pressure. 7-[2-Methoxyimino-2-(2-aminothiazol-4-yl)
acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-
carboxylic acid (syn-isomer) pivaloyloxymethyl ester
(0.083 g) was thus obtained.

20 NMR, δ (CDCl₃) : 1.14 (9H, s), 2.44 (3H, s),
3.30 (1H, d, J=18 Hz), 3.47 (1H, d, J=18 Hz), 4.04 (3H, s),
5.17 (1H, d, J=5 Hz), 5.27 (2H, b), 5.77 (1H, d, J=5 Hz),
5.82 (1H, d, J=5 Hz), 6.03 (1H, dd, J=5 Hz, 9 Hz),
6.35 (1H, d, J=12 Hz), 6.64 (1H, d, J=12 Hz), 6.88 (1H, s),
25 7.35 (1H, d, J=9 Hz), 8.59 (1H, s).

Example 3

7-Amino-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid benzhydryl ester (0.223 g) and 2-(2-tritylaminothiazol-4-yl)-2-methoxyiminoacetic acid (0.252 g) were reacted with each other and the reaction product was processed in the same manner as in Example 1, to obtain 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)acetamide]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer) benzhydryl ester (0.215 g).

NMR, δ (CDCl_3) : 2.35 (3H, s), 3.25 (1H, d, J=18 Hz), 3.45 (1H, d, J=18 Hz), 4.05 (3H, s), 5.14 (1H, d, J=5 Hz), 5.98 (1H, dd, J=5 Hz, 9 Hz), 6.27 (1H, d, J=12 Hz), 6.45 (1H, d, J=12 Hz), 6.72 (1H, s), 6.88 (1H, s), 6.99 (1H, broad s), 7.10-7.5 (26H, m), 8.54 (1H, s).

Examples 4-8

The following compounds were produced in the same manner as in Example 1:

Example 4

7-[2-Methoxyimino-2-(2-tritylaminothiazol-4-yl)acetamido]-3-(2-phenylvinyl)-3-cephem-4-carboxylic acid (syn-isomer) benzhydryl ester (yield 68%).

NMR, δ (CDCl_3) : 3.25 (2H, broad s), 4.04 (3H, s), 5.05 (1H, d, J=5 Hz), 5.91 (1H, d, J=5 Hz), 6.48 (1H, d, J=12 Hz), 6.60 (1H, d, J=12 Hz), 6.74 (1H, s), 6.95 (1H, s), 7.0-7.5 (32H, m).

Example 5

7-[2-Methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(2-furyl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer) benzhydryl ester (yield 62%).

5 NMR, δ (CDCl₃) : 3.50 (2H, broad s), 4.07 (3H, s),
5.11 (1H, d, J=5 Hz), 5.91 (1H, dd, J=5 Hz, 9 Hz),
6.1-6.4 (4H, m), 6.76 (1H, s), 6.88 (1H, s), 7.00 (1H,
broad s), 7.1-7.6 (27H, m).

Example 6

10 7-[2-(Methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(5-nitro-2-furyl)vinyl]-3-cephem-4-
carboxylic acid (syn-isomer) benzhydryl ester (yield 75%).

NMR, δ (CDCl₃) : 3.40 (1H, d, J=18 Hz),
3.63 (1H, d, J=18 Hz), 4.10 (3H, s), 5.32 (1H, d, J=5 Hz),
15 6.05 (1H, dd, J=5 Hz, 9 Hz), 6.19 (1H, d, J=12 Hz),
6.31 (1H, d, J=4 Hz), 6.53 (1H, d, J=12 Hz),
6.78 (1H, s), 6.86 (1H, s), 7.00 (1H, broad s),
7.13 (1H, d, J=4 Hz), 7.15-7.5 (26H, m).

Example 7

20 7-[2-Methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(o-fluorophenyl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer) benzhydryl ester (yield 71%).

NMR, δ (CDCl₃) : 3.23 (2H, broad s), 4.02 (3H, s),
5.03 (1H, d, J=5 Hz), 5.91 (1H, dd, J=5 Hz, 9 Hz),
25 6.57 (1H, d, J=12 Hz), 6.63 (1H, d, J=12 Hz), 6.72 (1H, s),

6.93 (1H, s), 6.95-7.5 (31H, m).

Example 8

7-[2-t-Butoxycarbonylmethoxyimino-2-(2-tritylamino-
thiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-
5 3-cephem-4-carboxylic acid (syn-isomer) benzhydryl ester
(yield 81%).

NMR, δ (CDCl_3) : 1.43 (9H, s), 2.36 (3H, s),
3.25 (1H, d, J=18 Hz), 3.55 (1H, d, J=18 Hz), 4.75 (2H, s),
5.14 (1H, d, J=5 Hz), 5.94 (1H, dd, J=5 Hz, 9 Hz),
10 6.27 (1H, d, J=12 Hz), 6.45 (1H, d, J=12 Hz), 6.80 (1H, s),
6.86 (1H, s), 6.99 (1H, broad s), 7.1-7.5 (25H, m),
8.53 (1H, s), 8.56 (1H, d, J=9 Hz).

Example 9

Production of 7-[2-methoxyimino-2-(2-tritylamino-
15 thiazol-4-yl)acetamido]-3-[2-(3,4-dimethyl-5-thiazolio)vinyl]-
3-cephem-4-carboxylic acid (syn-isomer) benzhydryl ester
iodide

7-[2-Methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-
20 carboxylic acid benzhydryl ester (0.164 mg) was dissolved
in benzene (5 ml), to which was added methyl iodide (1 ml).
The solution so obtained was stirred for 7 days so that a
precipitate was deposited. The precipitate was removed
by filtration, washed with benzene and dried under reduced
25 pressure, to afford 7-[2-methoxyimino-2-(2-tritylamino-

thiazol-4-yl)acetamido]-3-[2-(3,4-dimethyl-5-thiazolio)
vinyl]-3-cephem-4-carboxylic acid (syn-isomer) benzhydryl
ester iodide (0.122 mg).

NMR, δ (CDCl₃) : 2.30 (3H, s), 3.32 (1H, d, J=18 Hz),
5 3.65 (1H, d, J=18 Hz), 4.02 (3H, s), 4.06 (3H, s),
5.42 (1H, d, J=5 Hz), 5.92 (1H, dd, J=5 Hz, 9 Hz),
6.29 (1H, d, J=12 Hz), 6.56 (1H, d, J=12 Hz), 6.64 (1H, s),
6.89 (1H, s), 7.0-7.5 (27H, m), 10.19 (1H, s).

Example 10

10 Production of 7-[2-methoxyimino-2-(2-aminothiazol-
4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-
4-carboxylic acid (syn-isomer, cis-isomer) trifluoroacetate

7-[2-Methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-
15 carboxylic acid benzhydryl ester (0.11 g) was dissolved in
anisole (0.33 mg), to which was added trifluoroacetic acid
(1.1 ml) under ice-cooling. The solution so obtained was
stirred for 1 hour under ice-cooling and the reaction
solution was admixed with isopropyl ether (30 ml) to
20 deposit a precipitate. The precipitate was recovered by
filtration, washed with isopropyl ether and dried under
reduced pressure. 7-[2-Methoxyimino-2-(2-aminothiazol-4-
yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-
4-carboxylic acid (syn-isomer) trifluoroacetate (0.067 g)
25 was obtained.

NMR, δ (CD_3SOCD_3) : 2.44 (3H, s), 3.39 (1H, d, J=18 Hz),
 3.46 (1H, d, J=18 Hz), 3.84 (3H, s), 5.22 (1H, d, J=5 Hz),
 5.80 (1H, dd, J = 5 Hz, 9 Hz), 6.36 (1H, d, J=12 Hz),
 6.67 (1H, d, J=12 Hz), 6.76 (1H, s), 8.90 (1H, s),
 5 9.63 (1H, d, J=9 Hz).

Examples 11-16

The following compounds were prepared in the same manner as in Example 10.

Sodium salt of the compounds of Examples 12 and 13
 10 given below were produced by preparing the trifluoroacetate
 of the corresponding compounds in the same manner as in
 Example 10, dissolving said trifluoroacetate in an aqueous
 solution of 2 molar equivalents of sodium hydrogen carbonate,
 purifying chromatographically the resulting solution on a
 15 column of Diaion HP20 (100-fold volume) as eluted with water
 and aqueous 20% acetone, and freeze-drying the eluate
 containing the desired compound.

Example 11

7-[2-Methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
 20 3-(2-phenylvinyl)-3-cephem-4-carboxylic acid (syn-isomer,
 cis-isomer) trifluoroacetate (yield 79%).

NMR, δ (CD_3SOCD_3) : 3.17 (1H, d, J=18 Hz),
 3.42 (1H, d, J=18 Hz), 3.82 (3H, s), 5.20 (1H, d, J=5 Hz),
 5.76 (1H, dd, J=5 Hz, 9 Hz), 6.52 (1H, d, J=12 Hz),
 25 6.58 (1H, d, J=12 Hz), 6.73 (1H, s), 7.1-7.5 (5H, m),

9.57 (1H, d, J=9 Hz).

Example 12

7-[2-Methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(2-furyl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer,
5 cis-isomer) sodium salt (yield 13%).

NMR, δ (D₂O) : 3.51 (1H, d, J=18 Hz), 3.72 (1H, d,
J=18 Hz), 4.03 (3H, s), 5.39 (1H, d, J=5 Hz), 5.86 (1H, d,
J=5 Hz), 6.22 (1H, d, J=12 Hz), 6.44 (1H, d, J=12 Hz),
6.4-6.6 (2H, m), 7.07 (1H, s), 7.54 (1H, d, J=2 Hz).

10 Example 13

7-[2-Methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(5-nitro-2-furyl)vinyl]-3-cephem-4-carboxylic acid
(syn-isomer, trans-isomer) sodium salt (yield 53%).

15 NMR, δ (D₂O) : 3.57 (1H, d, J=18 Hz), 3.82 (1H, d,
J=18 Hz), 4.03 (3H, s), 5.34 (1H, d, J=5 Hz), 5.88 (1H, d,
J=5 Hz), 6.76 (1H, d, J=15 Hz), 6.79 (1H, d, J=4 Hz),
7.05 (1H, s), 7.46 (1H, d, J=15 Hz), 7.60 (1H, d, J=4 Hz).

Example 14

20 7-[2-Methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(o-fluorophenyl)vinyl]-3-cephem-4-carboxylic acid (syn-
isomer, mixed cis- and trans-isomers) trifluoroacetate (yield 84%).

25 NMR, δ (CD₃SOCD₃) : 3.12 (1H, d, J=18 Hz),
3.33 (1H, d, J=18 Hz), 3.77 (3H, s), 5.07 (1H, d, J=5 Hz),
5.65 (1H, dd, J=5 Hz, 9 Hz), 6.47 (2H, s), 6.63 (1H, s),
6.9-7.5 (4H, m), 9.42 (1H, d, J=9 Hz).

Example 15

7-[2-Methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(3,4-dimethyl-5-thiazolio)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer) di-trifluoroacetate (yield 73%).

5 NMR, δ (CD_3SOCD_3) : 2.42 (3H, s), 3.37 (1H, d,
J=18 Hz), 3.52 (1H, d, J=18 Hz), 3.82 (3H, s), 4.04 (3H, s),
5.24 (d, J=5 Hz), 5.80 (1H, dd, J=5 Hz, 9 Hz), 6.72 (3H, s),
9.56 (1H, d, J=9 Hz), 10.25 (1H, s).

Example 16

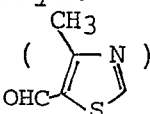
10 7-[2-Carboxymethoxyimino-2-(2-aminothiazol-4-yl)
acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-
carboxylic acid (syn-isomer,trans-isomer) trifluoroacetate (yield 58%).

NMR, δ (CD_3SOCD_3) : 2.37 (3H, s), 3.36 (1H, d,
J=18 Hz), 3.51 (1H, d, J=18 Hz), 4.62 (2H, s), 5.27 (1H, d,
15 J=5 Hz), 5.87 (1H, dd, J=5 Hz, 9 Hz), 6.37 (1H, d, J=12 Hz),
6.83 (1H, s), 8.93 (1H, s), 9.62 (1H, d, J=9 Hz).

Reference Example 2

Production of 7-amino-3-[2-(4-methylthiazol-5-yl)
vinyl]-3-cephem-4-carboxylic acid (trans-isomer) p-methoxy-
20 benzyl ester

(1) p-Methoxybenzyl 7-phenylacetamido-3-chloromethyl-
3-cephem-3-carboxylate (10.00 g, 20.52 mmol) and
triphenylphosphine (5.65 g, 21.5 mmol) were dissolved in
acetone (200 ml), to which sodium iodide (3.23 g, 21.5 mmol)
25 was added at ambient temperature. The resultant mixture

was stirred for 2 hours and concentrated to dryness under reduced pressure. To the solid residue were added methylene chloride (100 ml), 4-methylthiazol-5-yl-carboaldehyde () (26.07 g, 20.5 mmol) and aqueous saturated sodium

5 hydrogen carbonate solution (100 ml) successively, followed by stirring the resultant mixture for 16 hours at ambient temperature. The mixture obtained was allowed to stand until it separated into the aqueous phase and organic solvent phase. The organic phase was separated from the aqueous phase, and washed with aqueous 10% sodium bisulfite solution (250 ml) and then with aqueous saturated sodium chloride solution (250 ml). The organic phase as washed was dried over anhydrous magnesium sulfate and then concentrated under reduced pressure. To the residue was added methanol (200 ml) to deposit a precipitate which was then filtered out, washed with methanol and dried under reduced pressure. 7-Phenylacetamido-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (trans-isomer) p-methoxybenzyl ester was thus obtained as a light yellow colored powder (yield 1.20 g, 10%).

NMR, δ (CDCl_3) : 2.40 (3H, s), 3.60 (2H, broad s), 3.62 (2H, s), 3.78 (3H, s), 4.93 (1H, d, $J=5$ Hz), 5.20 (2H, s), 5.79 (dd, $J=5$ Hz, 9 Hz), 6.6-6.9 (4H, m), 7.0-7.4 (8H, m), 8.51 (1H, s).

25 (2) p-Methoxybenzyl 7-phenylacetamido-3-[2-(4-

methythiazol-5-yl)vinyl]-3-cephem-4-carboxylate (trans-isomer) (0.720 g, 1.28 mmol) was dissolved in methylene chloride (3 ml). The resultant solution was poured into a solution of phosphorus pentachloride (0.800 g, 3.84 mmol) and pyridine (1.04 ml, 12.8 mmol) in methylene chloride (20 ml) at -30°C. The resultant solution was stirred for 3 hours under ice-cooling and poured into methanol (20 ml) as pre-cooled to -30°C, followed by stirring the mixture for 1 hour at ambient temperature. The reaction solution obtained was poured into a mixture of aqueous saturated sodium chloride solution (20 ml) and methylene chloride (20 ml), and the resulting mixture was stirred for 1 hour. The mixture was allowed to stand until it separated into the aqueous phase and organic solvent phase. The aqueous phase separated out was extracted with methylene chloride (20 ml) and the methylene chloride extract was combined with the organic phase mentioned above. The combined organic phase was washed with aqueous saturated sodium hydrogen carbonate solution, dried over anhydrous magnesium sulfate and concentrated under reduced pressure. The residue obtained was purified chromatographically on a column of silica gel (Wako gel C-300) (20 g) as developed with benzene-ethyl acetate (3:1) as the development solvent. The titled compound, 7-amino-3-[2-(4-methythiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (trans-isomer) p-methoxy-

benzyl ester (0.443 g, 78%) was obtained.

NMR, δ (CDCl_3) : 1.83 (1H, broad s), 2.46 (1H, s),
3.63 (1H, d, J=18 Hz), 3.71 (1H, d, J=18 Hz), 3.77 (3H, s),
4.72 (1H, d, J=5 Hz), 4.94 (1H, d, J=5 Hz), 5.23 (2H, s),
5 6.85 (1H, d, J=16 Hz), 6.8-6.9 (2H, m), 7.22 (1H, d, J=16 Hz),
7.3-7.4 (2H, m), 8.52 (1H, s).

Example 17

Production of 7-[2-methoxyimino-2-(2-tritylamino-
thiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-
10 3-cephem-4-carboxylic acid p-methoxybenzyl ester (syn-isomer,
trans-isomer)

p-Methoxybenzyl 7-amino-3-[2-(4-methylthiazol-5-yl)
vinyl]-3-cephem-4-carboxylate (trans-isomer) as prepared
by the method of Reference Example 2 as above and 2-(trityl-
15 aminothiazol-4-yl)-2-methoxyiminoacetic acid (syn-isomer)
were reacted with each other and the reaction product was
processed in the same manner as in Example 1 to give the
titled compound in a yield of 72%.

NMR, δ (CDCl_3) : 2.42 (3H, s), 3.57 (1H, d, J=18 Hz),
20 3.67 (1H, d, J=18 Hz), 3.73 (3H, s), 4.02 (3H, s),
5.01 (1H, d, J=5 Hz), 5.17 (2H, s), 5.84 (1H, dd, J=5 Hz,
9 Hz), 6.63 (1H, s), 6.83 (1H, d, J=16 Hz), 6.8-7.5 (20H, m),
8.49 (1H, s).

Example 18

25 Production of 7-[2-methoxyimino-2-(2-aminothiazol-

4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid sodium salt (syn-isomer, trans-isomer)

p-Methoxybenzyl 7-[2-methoxyimino-2-(2-trityl-aminothiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylate (syn-isomer, trans-isomer)
5 was treated with trifluoroacetic acid and processed in the same manner as in Example 10 to give a trifluoroacetate of the titled compound (as the carboxylic acid). This trifluoroacetate obtained was dissolved in aqueous sodium
10 hydrogen carbonate solution for neutralization and then purified chromatographically on a column of Diaion HP20 (100 fold-volume) as eluted with water and aqueous 20% acetone. The eluate containing the titled compound was lyophilized to afford the titled compound in a yield of
15 82%.

NMR, δ (D_2O) : 2.50 (3H, s), 3.86 (2H, broad s), 4.06 (3H, s), 5.34 (1H, d, J=5 Hz), 5.87 (1H, d, J=5 Hz), 6.97 (1H, d, J=16 Hz), 7.06 (1H, d, J=16 Hz), 7.08 (1H, s), 8.77 (1H, s).

20 Example 19

Production of 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid pivaloyloxymethyl ester (syn-isomer, trans-isomer).

25 7-[2-Methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-

3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic
acid sodium salt (syn-isomer, trans-isomer) (0.030 g,
0.06 mmol) was dissolved in dimethylformamide (3 ml). To
the resultant solution was added a solution in dimethyl-
5 formamide (1 ml) of iodomethyl pivalate (as prepared by
reacting chloromethyl pivalate (0.090 g, 0.60 mmol) with
sodium iodide (0.090 g, 0.60 mmol) in acetone) under ice-
cooling, followed by stirring the resultant mixture for
10 minutes. The reaction solution as obtained were admixed
10 with ice-water (20 ml) and ethyl acetate (20 ml), stirred
thoroughly and then allowed to stand until the mixture
separated into aqueous phase and organic phase. The
organic phase was separated from the aqueous phase and
washed twice with water (10 ml) and then with aqueous
15 saturated NaCl solution (10 ml). The organic phase as
washed was subsequently dried over anhydrous magnesium
sulfate and concentrated under reduced pressure. The
residue was purified chromatographically on a column of
silica-gel (Wako-gel C-300) (5 g) as developed with ethyl
20 acetate. The titled compound was thus obtained (yield
0.025 g, 67%).

NMR, δ (CDCl_3) : 1.21 (9H, s), 2.48 (3H, s),
3.68 (1H, d, $J=18$ Hz), 3.78 (1H, d, $J=18$ Hz),
4.04 (3H, s), 5.12 (1H, d, $J=5$ Hz), 5.89 (2H, s),
25 5.97 (1H, dd, $J=5$ Hz, 9 Hz), 6.86 (1H, s), 6.98 (1H, d,

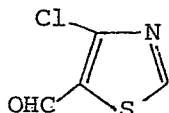
J=16 Hz), 7.33 (1H, d, J=16 Hz), 7.52 (1H, d, J=9 Hz),
8.57 (1H, s).

Reference Example 3

Production of 4-chloro-thiazol-5-yl-carboaldehyde

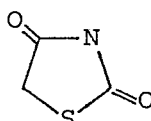
5

of the formula



10

Phosphorus oxychloride (122.7 g) was added dropwise
to dimethylformamide (73.1 g) under ice-cooling, and the
mixture obtained was stirred for 30 minutes (for preparation
of Vilsmeier reagent). The mixture was then admixed with

thiazoline-2,4-dione () (23.4 g), followed by

15

heating at 100°C for 3 hours. The reaction solution was
cooled to ambient temperature, poured onto ice (200 g),
neutralized by addition of sodium acetate and then extracted
4 times with 200 ml-portions of methylene chloride. The
resultant extract in methylene chloride was washed with a
small volume of saturated aqueous sodium hydrogen carbonate
solution, dried over anhydrous magnesium sulfate and con-
centrated under reduced pressure. The residue obtained
was purified chromatographically on a column of silica gel
as developed with benzene-ethyl acetate (10:1) as eluent.
The titled compound (1.10 g) was obtained as light yellow
colored crystals.

20

NMR, δ (CDCl₃) : 8.93 (1H, d, J=1 Hz), 10.03 (1H, d,

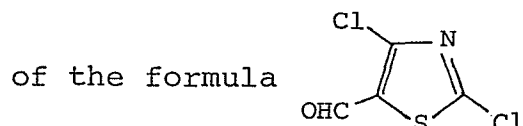
25

J=1 Hz).

MS (m/e) : 148 (M^+ + 1)

Reference Example 4

Production of 2,4-dichloro-thiazol-5-yl-carboaldehyde



To a solution of dimethylformamide (73.1 g) in dichloroethylene (200 ml) was added dropwise phosphorus oxychloride (122.7 g) under ice-cooling, followed by stirring for 30 minutes (for preparation of Vilsmeier reagent). The resultant solution was admixed with thiazolin-2,4-dione (23.4 g) and heated for 1 hour under refluxing. The reaction solution obtained was cooled to ambient temperature, poured onto ice (200 g), neutralized by addition of sodium acetate and then extracted 3 times with 200 ml-portions of methylene chloride. The resultant extract in methylene chloride was washed with a small volume of saturated aqueous sodium hydrogen carbonate, dried over anhydrous magnesium sulfate, and then concentrated under reduced pressure. The residue obtained was purified chromatographically on a column of silica-gel as developed with benzene-ethyl acetate (10:1) as eluent. 4-Chloro-thiazol-5-yl-carboaldehyde (0.34 g) was afforded, and the titled compound (2.05 g) was also obtained as light yellow colored crystals.

NMR, δ (CDCl_3) : 9.90 (1H, s)

MS (m/e) : 182 (M^+ + 1)

Reference Example 5

Production of 7-phenylacetamido-3-[2-(4-chlorothiazol-
5-yl)vinyl]-3-cephem-4-carboxylic acid (cis-isomer) p-methoxy-
benzyl ester.

p-Methoxybenzyl 7-phenylacetamido-3-chloromethyl-3-
cephem-4-carboxylate (3.265 g, 6.71 mmol) and triphenyl-
phosphine (1.859 g, 7.05 mmol) were dissolved in dimethyl-
formamide (20 ml). The resultant solution was admixed with
sodium iodide (1.056 g, 7.05 mmol) at ambient temperature
and stirred for 2 hours. The reaction solution obtained
was concentrated to dryness under reduced pressure, and the
residue was taken up into methylene chloride (10 ml). To
the resultant solution in methylene chloride were added
4-chloro-thiazol-5-yl-carboaldehyde (1.100 g) which was
obtained in Reference Example 3 described hereinbefore,
and then saturated aqueous sodium hydrogen carbonate (10 ml).
The mixture obtained was stirred for 6 hours at ambient
temperature and then was left until it separated into the
aqueous phase and organic phase. The aqueous phase as
separated was extracted with methylene chloride (10 ml).
The extract in methylene chloride and the organic solvent
phase were combined together, dried over anhydrous magnesium
sulfate and concentrated under reduced pressure. The

residue obtained was purified by flash-column chromatography on a column of silica-gel (Wako-gel C-300) as developed with benzene-ethyl acetate (5:1) as eluent solvent. The titled compound was obtained (yield 2.891 g, 74%).

NMR, δ (CDCl_3) : 3.15 (1H, d, J=18 Hz), 3.42 (1H, d=18 Hz), 3.61 (2H, s), 3.74 (3H, s), 5.00 (1H, d, J=5 Hz), 5.06 (2H, s), 5.84 (1H, dd, J=5 Hz, 9 Hz), 6.14 (1H, d, J=9 Hz), 6.27 (1H, d, J=12 Hz), 6.56 (1H, d, J=12 Hz), 6.7-6.75 (2H, m), 7.05-7.4 (7H, m), 8.50 (1H, s).

Reference Example 6

Production of 7-amino-3-[2-(4-chlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (cis-isomer) p-methoxybenzyl ester.

p-Methoxybenzyl 7-phenylacetamido-3-[2-(4-chlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylate (cis-isomer) (2.452 g, 4.21 mmol) as prepared in the above Reference Example 5 was dissolved in methylene chloride (10 ml). The resultant solution was poured into a solution of phosphorus pentachloride (2.630 g, 12.63 mmol) and pyridine (3.4 ml, 42 mmol) in methylene chloride (40 ml) at -30°C under cooling. The reaction solution obtained was stirred for 3 hours under ice-cooling and poured into methanol (40 ml) as pre-cooled to -30°C , followed by stirring the resultant mixture for 1 hour at ambient temperature. The

mixture was then added into a mixture of saturated aqueous sodium chloride (100 ml) and methylene chloride (100 ml) and stirred for 1 hour. The mixture obtained was left until it separated into the aqueous phase and organic solvent phase. The aqueous phase was separated and extracted with methylene chloride (50 ml). The extract in methylene chloride was added to the above organic solvent phase, which was then washed with saturated aqueous sodium hydrogen carbonate, dried over anhydrous magnesium sulfate and concentrated under reduced pressure. The residue obtained was purified by flash-column chromatography on a column of silica-gel (Wako-gel C-300) as developed with benzene-ethyl acetate (3:1) as eluent. The titled compound was obtained (yield 1.543 g, 79%).

NMR, δ (CDCl_3) : 1.75 (2H, broad s), 3.20 (1H, d, $J=18$ Hz), 3.44 (1H, d, $J=18$ Hz), 3.75 (3H, s), 4.77 (1H, d, $J=5$ Hz), 4.97 (1H, d, $J=5$ Hz), 5.08 (2H, s), 6.31 (1H, d, $J=12$ Hz), 6.53 (1H, d, $J=12$ Hz), 6.7-6.85 (2H, m), 7.1-7.25 (2H, m), 8.50 (1H, s).

Reference Example 7

Production of 7-phenylacetamido-3-[2-(2,4-dichloro-thiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (cis-isomer) p-methoxybenzyl ester

p-Methoxybenzyl 7-phenylacetamido-3-chloromethyl-3-

cephem-4-carboxylate was reacted with 2,4-dichloro-thiazol-5-yl-carboaldehyde as obtained in the Reference Example 4, in the same manner as in the Reference Example 5. The titled compound was produced in a yield of 78%.

5 NMR, δ (CDCl₃) : 3.19 (1H, d, J=18 Hz), 3.40 (1H, d, J=18 Hz), 5.01 (1H, d, J=5 Hz), 5.09 (2H, s), 5.88 (1H, dd, J=5 Hz, 9 Hz), 6.10 (1H, d, J=9 Hz), 6.22 (1H, d, J=12 Hz), 6.46 (1H, d, J=12 Hz), 7.7-7.85 (2H, m), 7.1-7.45 (7H, m).

Reference Example 8

10 Production of 7-amino-3-[2-(2,4-dichlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (cis-isomer) p-methoxybenzyl ester

p-Methoxybenzyl 7-phenylacetamido-3-[2-(2,4-dichloro-thiazol-5-yl)vinyl]-3-cephem-4-carboxylate (cis-isomer)
15 was treated with phosphorus pentachloride and pyridine in the same manner as in the Reference Example 6 to afford the titled compound in a yield of 73%.

NMR, δ (CDCl₃) : 1.80 (2H, broad s), 3.20 (1H, d, J=18 Hz), 3.42 (1H, d, J=18 Hz), 3.75 (3H, s), 4.79 (1H, d, J=5 Hz), 4.98 (1H, d, J=5 Hz), 5.10 (2H, s), 6.26 (1H, d, J=12 Hz), 6.44 (1H, d, J=12 Hz), 7.7-7.85 (2H, m),
20 7.1-7.4 (7H, m).

Example 20

Production of 7-[2-methoxyimino-2-(2-tritylamino-thiazol-4-yl)acetamido]-3-[2-(4-chlorothiazol-5-yl)vinyl]-
25

3-cephem-4-carboxylic acid (syn-isomer, cis-isomer)
p-methoxybenzyl ester.

p-Methoxybenzyl 7-amino-3-[2-(4-chlorothiazol-5-yl)
vinyl]-3-cephem-4-carboxylate (cis-isomer) (1.205 g, 2.60
5 mmol) and 2-(2-tritylaminothiazol)-2-methoxyimino-acetic
acid (syn-isomer) (1.153 g, 2.60 mmol) were dissolved in
methylene chloride (30 ml), to which were added pyridine
(0.84 ml, 10.4 mmol) and then phosphorus oxychloride
(0.33 ml, 3.64 mmol) at -20°C under cooling. The reaction
10 solution was stirred for 20 minutes at 0°C and poured
into a mixture of ice-water (100 ml) and ethyl acetate
(100 ml), followed by stirring. The mixture obtained was
allowed to stand until it separated into the aqueous phase
and organic phase. The organic phase was separated from
15 the aqueous phase, washed with saturated aqueous sodium
hydrogen carbonate, dried over anhydrous magnesium sulfate
and then concentrated under reduced pressure. The residue
obtained was purified by flash-column chromatography on a
column of silica-gel (Wako-gel C-300) (50 g) as developed
20 with benzene-ethyl acetate (5:1) as eluent. The titled
compound was obtained (yield 1.665 g, 72%).

NMR, δ (CDCl₃) : 3.20 (1H, d, J=18 Hz), 3.44 (1H,
d, J=18 Hz), 3.76 (3H, s), 4.03 (3H, s), 5.07 (2H, s),
5.08 (1H, d, J=5 Hz), 5.94 (1H, dd, J=5 Hz, 9 Hz),
25 6.33 (1H, d, J=12 Hz), 6.59 (1H, d, J=12 Hz),

6.7-7.4 (22H, m), 8.50 (1H, s).

Example 21

Production of 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(4-chlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, cis-isomer) sodium salt.

p-Methoxybenzyl 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)acetamido]-3-[2-(4-chlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylate (syn-isomer, cis-isomer) (0.856 g, 0.962 mmol) was dissolved in anisole (2 ml), to which was added dropwise trifluoroacetic acid (8 ml) under ice-cooling. The mixture obtained was stirred for 1 hour under ice-cooling and then admixed with isopropyl ether (50 ml) to deposit a precipitate. The precipitate was removed by filtration, washed with isopropyl ether and dried under reduced pressure.

The titled compound (the carboxylic acid) was obtained in the form of its trifluoroacetate (0.586 g) (as an acid-addition salt with trifluoroacetic acid). The compound obtained was mixed with water (3 ml) and sodium hydrogen carbonate (0.242 g), and the resulting solution was purified by column-chromatography on a column of Diaion HP-20 as eluted with water and then with 30% aqueous acetone. The fractions of the eluate containing the desired compound were combined together and concentrated under reduced pressure, followed by lyophilization. The titled compound was obtained (yield 0.433 g, 82%).

NMR, δ (D_2O) : 3.43 (1H, d, $J=18$ Hz), 3.70 (1H, d, $J=18$ Hz), 4.03 (3H, s), 5.42 (1H, d, $J=5$ Hz), 5.90 (1H, d, $J=5$ Hz), 6.48 (1H, d, $J=12$ Hz), 6.71 (1H, d, $J=12$ Hz), 7.06 (1H, s), 8.87 (1H, s).

5 Example 22

Production of 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(4-chlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, cis-isomer) pivaloyloxymethyl ester.

10 7-[2-Methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(4-chlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, cis-isomer) sodium salt (0.104 g, 0.188 mmol) was dissolved in dimethylformamide (3 ml). Under ice-cooling, the resultant solution was admixed with a solution
15 of iodomethyl pivalate [as prepared by reacting chloromethyl pivalate (0.141 g) with sodium iodide (0.282 g) in acetone] in dimethylformamide (1 ml), and the mixture obtained was stirred for 10 minutes. To the reaction solution were added ice-water (20 ml) and ethyl acetate (20 ml). The
20 resulting mixture was well agitated and then allowed to stand until it separated into the aqueous phase and organic phase. The organic phase was separated from the aqueous phase, washed twice with 10 ml-portions of water and with 10 ml of saturated aqueous sodium chloride, dried over
25 anhydrous magnesium sulfate and then concentrated under

reduced pressure. The residue obtained was purified by flash-column chromatography on a column of silica-gel (Wako-gel C-300) (10 g) as eluted with ethyl acetate. The titled compound was afforded (yield 0.940 g, 78%).

5 NMR, δ (CDCl_3) : 1.13 (9H, s), 3.30 (1H, d, J=18 Hz),
3.51 (1H, d, J=18 Hz), 5.17 (1H, d, J=5 Hz), 5.43 (2H,
broad s), 5.75 (1H, d, J=6 Hz), 5.80 (1H, d, J=6 Hz),
6.06 (1H, dd, J=5 Hz, 9 Hz), 6.40 (1H, d, J=12 Hz),
6.66 (1H, d, J=12 Hz), 6.78 (1H, s), 7.65 (1H, d, J=9 Hz),
10 8.54 (1H, s).

Examples 23-28

The following compounds were produced in the same manner as in Example 20 described above.

Example 23

15 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(thiazol-2-yl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer, trans-isomer) diphenylmethyl ester
(Yield 72%).

20 NMR, δ (CDCl_3) : 3.45 (1H, d, J=18 Hz),
3.67 (1H, d, J=18 Hz), 4.04 (3H, s), 5.16 (1H, d, J=5 Hz),
5.97 (1H, dd, J=5 Hz, 9 Hz), 6.58 (1H, s), 6.73 (1H, s),
6.85 (1H, s), 6.9-7.5 (29H, m), 7.74 (1H, d, J=3 Hz).

Example 24

25 7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(2-methylthiazol-5-yl)vinyl]-3-cephem-4-

carboxylic acid (syn-isomer, trans-isomer) diphenylmethyl ester (Yield 68%).

NMR, δ (CDCl₃) : 2.63 (3H, s), 3.56 (2H, broad s), 4.04 (3H, s), 5.06 (1H, d, J=5 Hz), 5.88 (1H, dd, J=5 Hz, 9 Hz), 6.73 (1H, s), 6.82 (1H, d, J=16 Hz), 6.98 (1H, s), 7.0-7.5 (H₂₉, m).

Example 25

7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl) acetamido]-3-[2-(2-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, cis-isomer) diphenylmethyl ester (Yield 76%)

NMR, δ (CDCl₃) : 2.60 (3H, s), 3.27 (1H, d, J=18 Hz), 3.48 (1H, d, J=18 Hz), 4.04 (3H, s), 5.16 (1H, d, J=5 Hz), 5.97 (1H, dd, J=5 Hz, 9 Hz), 6.13 (1H, d, J=12 Hz), 6.41 (1H, d, J=12 Hz), 6.71 (1H, s), 6.85 (1H, s), 6.9-7.5 (28H, m).

Example 26

7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl) acetamido]-3-[2-(thiazol-4-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, cis-isomer) p-methoxybenzyl ester (Yield 75%)

NMR, δ (CDCl₃) : 3.40 (1H, d, J=18 Hz), 3.62 (1H, d, J=18 Hz), 3.77 (3H, s), 4.04 (3H, s), 5.10 (1H, d, J=5 Hz), 5.11 (2H, s), 5.89 (1H, dd, J=5 Hz, 9 Hz), 6.53 (2H, s), 6.7-7.5 (23H, m), 8.66 (1H, d, J=2 Hz).

Example 27

7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(thiazol-5-yl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer, cis-isomer) diphenylmethyl ester

5 (Yield 69%)

NMR, δ (CDCl₃) : 3.27 (1H, d, J=18 Hz), 3.46 (1H, d,
J=18 Hz), 4.04 (1H, d, J=5 Hz), 5.96 (1H, dd, J=5 Hz, 9 Hz),
6.23 (1H, d, J=12 Hz), 6.50 (1H, d, J=12 Hz), 6.71 (1H, s),
6.83 (1H, s), 6.9-7.5 (27H, m), 7.61 (1H, s), 8.57 (1H, s).

10 Example 28

7-[2-methoxyimino-2-(2-tritylaminothiazol-4-yl)
acetamido]-3-[2-(2,4-dichlorothiazol-5-yl)vinyl]-3-cephem-
4-carboxylic acid (syn-isomer, cis-isomer) p-methoxybenzyl
ester (Yield 81%)

15 NMR, δ (CDCl₃) : 3.21 (1H, d, J=18 Hz), 3.42 (1H, d,
J=18 Hz), 3.76 (3H, s), 4.04 (3H, s), 5.09 (1H, d, J=5 Hz),
5.11 (2H, s), 5.95 (1H, dd, J=5 Hz, 9 Hz), 6.25 (1H, d,
J=12 Hz), 6.47 (1H, d, J=12 Hz), 6.7-7.4 (22H, m).

Examples 29-34

20 The following compounds in the form of sodium salt
or trifluoroacetate were produced in the same manner as in
the foregoing Example 21.

Example 29

25 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(thiazol-2-yl)vinyl]-3-cephem-4-carboxylic acid

(syn-isomer, trans-isomer) sodium salt (Yield 82%)

NMR, δ (D_2O) : 3.82 (2H, broad s), 4.02 (3H, s),
5.32 (1H, d, $J=5$ Hz), 5.85 (1H, d, $J=5$ Hz), 6.99 (1H, d,
 $J=16$ Hz), 7.03 (1H, s), 7.46 (1H, d, $J=16$ Hz), 7.49 (1H, d,
5 $J=3$ Hz), 7.76 (1H, d, $J=3$ Hz).

Example 30

7-[2-(methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(2-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer, trans-isomer) trifluoroacetate (Yield 88%)

10 NMR, δ (CD_3SOCD_3) : 2.62 (3H, s), 3.75 (2H, broad s),
3.83 (3H, s), 5.18 (1H, d, $J=5$ Hz), 5.75 (1H, dd, $J=5$ Hz,
9 Hz), 6.75 (1H, s), 7.13 (2H, s), 7.60 (1H, s), 9.58 (1H,
d, $J=9$ Hz).

Example 31

15 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(2-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer, cis-isomer) trifluoroacetate (Yield 78%)

NMR, δ (CD_3SOCD_3) : 2.59 (3H, s), 3.41 (1H, d, $J=18$ Hz),
3.53 (1H, d, $J=18$ Hz), 3.84 (3H, s), 5.28 (1H, d, $J=5$ Hz),
20 5.82 (1H, dd, $J=5$ Hz, $J=9$ Hz), 6.22 (1H, d, $J=12$ Hz),
6.63 (1H, d, $J=12$ Hz), 6.73 (1H, s), 7.57 (1H, s),
9.60 (1H, d, $J=9$ Hz).

Example 32

25 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(thiazol-4-yl)vinyl]-3-cephem-4-carboxylic acid

(syn-isomer, cis-isomer) sodium salt (Yield 74%)

NMR, δ (D_2O) : 3.45 (1H, d, J=18 Hz), 3.58 (1H, d, J=18 Hz), 4.03 (3H, s), 5.33 (1H, d, J=5 Hz), 5.84 (1H, d, J=5 Hz), 6.56 (1H, d, J=12 Hz), 6.71 (1H, d, J=12 Hz),
5 7.06 (1H, s), 7.51 (1H, d, J=2 Hz), 8.99 (1H, d, J=2 Hz).

Example 33

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(thiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid
(syn-isomer, cis-isomer) sodium salt (Yield 78%)

10 NMR, δ (D_2O) : 3.48 (1H, d, J=18 Hz), 3.70 (1H, d, J=18 Hz), 4.05 (1H, s), 5.45 (1H, d, 2J=5 Hz), 5.90 (1H, d, J=5 Hz), 6.39 (1H, d, J=12 Hz), 6.81 (1H, d, J=12 Hz),
7.08 (1H, s), 7.86 (1H, s), 8.90 (1H, s).

Example 34

15 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(2,4-dichlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer, cis-isomer) sodium salt (Yield 78%)

NMR, δ (D_2O) : 3.46 (1H, d, J=18 Hz), 3.67 (1H, d, J=18 Hz), 4.04 (3H, s), 5.43 (1H, d, J=5 Hz), 5.91 (1H, d, J=5 Hz), 6.45 (1H, d, J=12 Hz), 6.64 (1H, d, J=12 Hz),
20 7.08 (1H, s).

Examples 35-39

The following compounds were produced in the same
manner as in Example 22 described hereinbefore.

25 Example 35

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(2-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer, trans-isomer) (5-methyl-2-oxo-1,3-dioxolen-
4-yl)methyl ester (Yield 62%)

5 NMR, δ (CDCl₃) : 2.21 (3H, s), 2.69 (3H, s),
3.65 (1H, d, J=18 Hz), 3.75 (1H, d, J=18 Hz), 4.04 (3H, s),
4.93 (1H, d, J=16 Hz), 5.12 (1H, J=5 Hz), 5.14 (1H, d,
J=16 Hz), 5.4 (2H, broad), 5.99 (1H, dd, J=5 Hz, J=9 Hz),
6.81 (1H, s), 6.92 (1H, d, J=16 Hz), 7.24 (1H, d, J=16 Hz),
10 7.53 (1H, s), 7.64 (1H, d, J=9 Hz).

Example 36

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(2-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic
acid (syn-isomer, cis-isomer) (5-methyl-2-oxo-1,3-dioxolen-
15 4-yl)methyl ester (Yield 69%)

 NMR, δ (CDCl₃) : 2.08 (3H, s), 2.64 (3H, s),
3.45 (1H, d, J=18 Hz), 3.54 (1H, d, J=18 Hz), 4.04 (3H, s),
4.80 (1H, d, J=16 Hz), 4.99 (1H, d, J=16 Hz), 5.22 (1H, d,
J=5 Hz), 5.4 (2H, broad), 6.10 (dd, J=5 Hz, 9 Hz),
20 6.17 (1H, d, J=12 Hz), 6.60 (1H, d, J=12 Hz), 6.78 (1H, s),
7.46 (1H, s), 7.72 (1H, d, J=9 Hz)

Example 37

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
3-[2-(thiazol-4-yl)vinyl]-3-cephem-4-carboxylic acid
25 (syn-isomer, cis-isomer) pivaloyloxymethyl ester (Yield 72%)

NMR, δ (CDCl₃) : 1.16 (9H, s), 3.48 (1H, d, J=18 Hz),
 3.68 (1H, d, J=18 Hz), 4.04 (3H, s), 5.16 (1H, d, J=5 Hz),
 5.75 (1H, d, J=6 Hz), 5.86 (1H, d, J=6 Hz), 5.94 (1H, dd,
 J=5 Hz, 9 Hz), 6.51 (1H, d, J=12 Hz), 6.58 (1H, d, J=12 Hz),
 5 6.88 (1H, s), 7.19 (1H, d, J=2 Hz), 8.66 (1H, d, J=2 Hz).

Example 38

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
 3-[2-(thiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid
 (syn-isomer, cis-isomer) pivaloyloxymethyl ester (Yield 76%)

10 NMR, δ (CDCl₃) : 1.13 (9H, s), 3.32 (1H, d, J=18 Hz),
 3.50 (1H, d, J=18 Hz), 4.04 (3H, s), 5.19 (1H, d, J=5 Hz),
 5.74 (1H, d, J=6 Hz), 5.81 (1H, d, J=6 Hz), 6.02 (1H, dd,
 J=5 Hz, 9 Hz), 6.35 (1H, d, J=12 Hz), 6.68 (1H, d, J=12 Hz),
 6.88 (1H, s), 7.41 (1H, d, J=9 Hz), 7.75 (1H, s), 8.66 (1H, s).

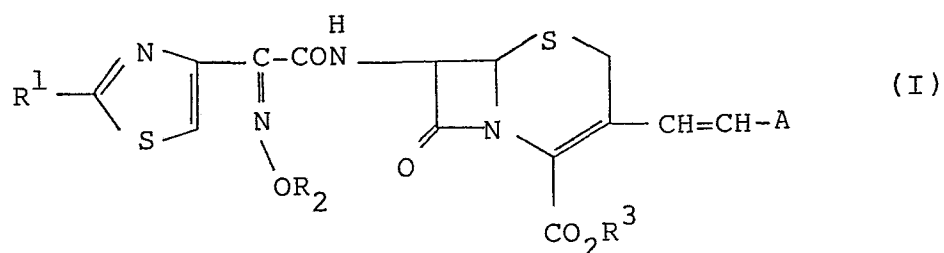
15 Example 39

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-
 3-[2-(2,4-dichlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylic
 acid (syn-isomer, cis-isomer) pivaloyloxymethyl ester
 (Yield 71%)

20 NMR, δ (CDCl₃) : 1.16 (9H, s), 3.30 (1H, d, J=18 Hz),
 3.52 (1H, d, J=18 Hz), 4.05 (3H, s), 5.16 (1H, d, J=6 Hz),
 5.78 (1H, d, J=6 Hz), 5.81 (1H, d, J=6 Hz), 6.05 (1H, dd,
 J=5 Hz, 9 Hz), 6.38 (1H, d, J=12 Hz), 6.58 (1H, d, J=12 Hz),
 6.91 (1H, s).

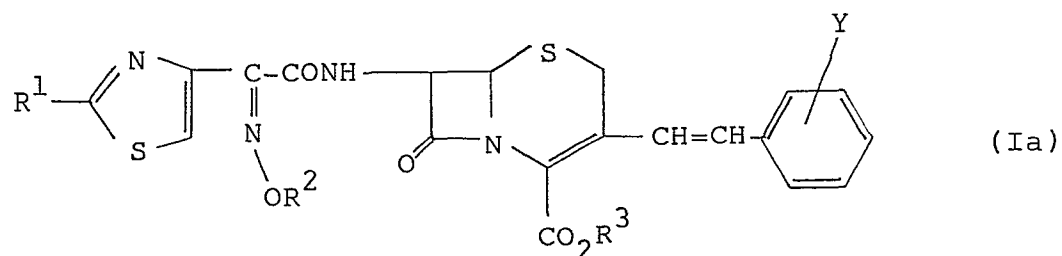
What we claim is:

1. A cephalosporin compound of the general formula (I)



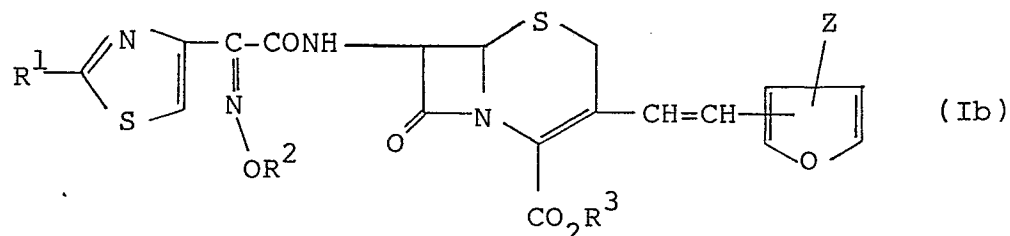
wherein R^1 is an amino group or a protected amino group;
 R^2 is a lower alkyl group, a carboxymethyl group or a
 protected carboxymethyl group; R^3 is a hydrogen atom,
 a salt-forming cation or a carboxyl-protecting group;
 A is an unsubstituted or substituted phenyl group, an
 unsubstituted or substituted furyl group, an unsubstituted
 or substituted thiazolyl group or an unsubstituted or
 substituted 3-lower-alkylthiazolio group, and a pharma-
 ceutically acceptable salt or ester of said cephalosporin
 compound.

2. A cephalosporin compound as claimed in Claim 1 which is of the general formula (Ia)



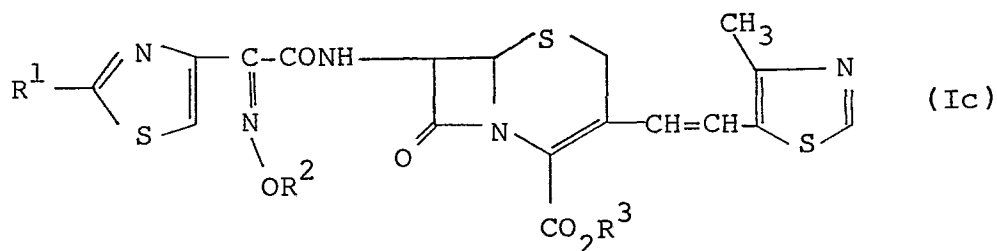
wherein R^1 is an amino group or a protected amino group, R^2 is a lower alkyl group, a carboxymethyl group or a protected carboxymethyl group, R^3 is a hydrogen atom, a salt-forming cation or a carboxyl-protecting group, and Y is a hydrogen atom, a lower alkyl group, a lower alkoxy group or a halogen atom.

3. A cephalosporin compound as claimed in Claim 1 which is of the general formula (Ib)



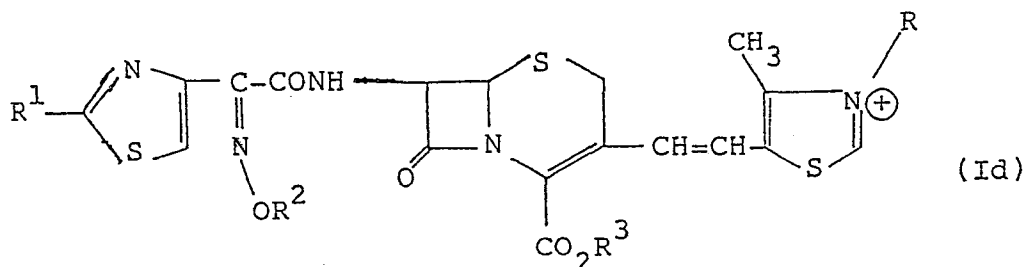
wherein R¹ is an amino group or a protected amino group, R² is a lower alkyl group, a carboxymethyl group or a protected carboxymethyl group, R³ is a hydrogen atom, a salt-forming cation or a carboxyl-protecting group, Z is a hydrogen atom, nitro group or a halogen atom.

4. A cephalosporin compound as claimed in Claim 1 which is of the general formula (Ic)



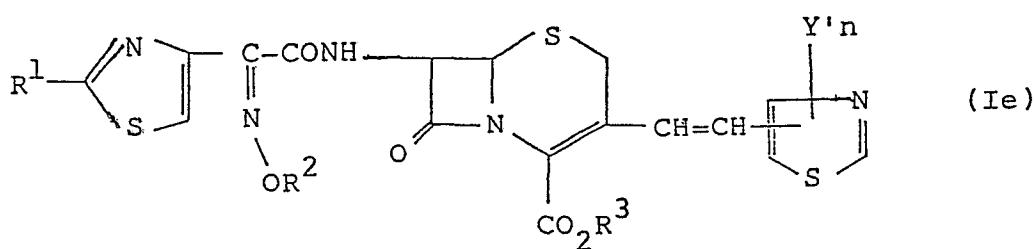
wherein R¹ is an amino group or a protected amino group, R² is a lower alkyl group, a carboxymethyl group or a protected carboxymethyl group, and R³ is a hydrogen atom, a salt-forming cation or a carboxyl-protecting group.

5. A cephalosporin compound as claimed in Claim 1 which is of the general formula (Id)



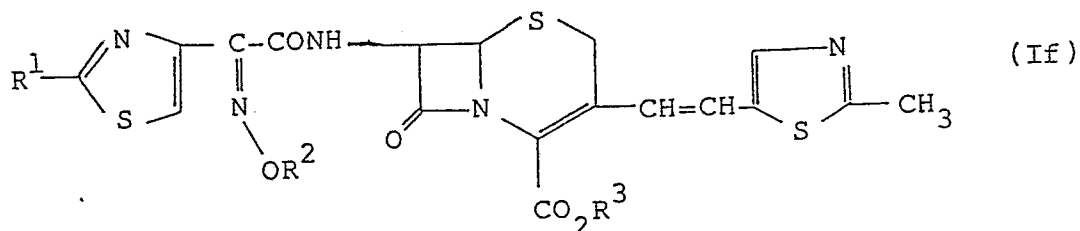
wherein R^1 is an amino group or a protected amino group, R^2 is a lower (C_1-C_6) alkyl group, a carboxymethyl group or a protected carboxymethyl group, R^3 is a hydrogen atom, a salt-forming cation or a carboxyl-protecting group, and R is a lower alkyl group.

6. A cephalosporin compound as claimed in Claim 1 which is of the general formula (Ie)



wherein R^1 is an amino group or a protected amino group, R^2 is a lower (C_1-C_6) alkyl group, a carboxymethyl group or a protected carboxymethyl group, R^3 is a hydrogen atom, a salt-forming cation or a carboxyl-protecting group, and Y' is a hydrogen atom or a halogen atom, and n is a whole number of 1 or 2.

7. A cephalosporin compound as claimed in Claim 1 which is of the general formula (If)



wherein R^1 is an amino group or a protected amino group, R^2 is a lower ($C_1 - C_6$) alkyl group, a carboxymethyl group or a protected carboxymethyl group, and R^3 is a hydrogen atom, a salt-forming cation or a carboxyl-protecting group.

8. A compound as claimed in Claims 1 to 7 in which R^1 is an amino group, R^2 is a methyl group or a carboxymethyl group, and R^3 is sodium atom, benzhydryl group, p-methoxybenzyl group, diphenylmethyl group, pivaloyloxymethyl group or (5-methyl-2-oxo-1,3-dioxolene-4-yl)-methyl group.

9. A compound as claimed in Claim 1 which is selected from:-

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-(2-phenylvinyl)-3-cephem-4-carboxylic acid (syn-isomer, trans-isomer, or syn-isomer, cis-isomer)

and its trifluoroacetate; and

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(o-fluorophenyl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, trans-isomer, or syn-isomer, cis-isomer) and its trifluoroacetate.

10. A compound as claimed in Claim 1 which is selected from:-

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(2-furyl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, trans-isomer, or syn-isomer, cis-isomer)

and its sodium salt;and

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(5-nitro-2-furyl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, trans-isomer, or syn-isomer, cis-isomer) and its sodium salt.

11. A compound as claimed in Claim 1 which is selected from:-

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(thiazol-2-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, trans-isomer, or syn-isomer, cis-isomer);

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(thiazol-4-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, cis-isomer) and its sodium salt and its pivaloyloxymethyl ester; and

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(thiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (cyn-isomer, cis-isomer), its sodium salt, and its pivaloyloxymethyl ester.

12. A compound as claimed in Claim 1 which is selected from:-

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, trans-isomer, or syn-isomer, cis-isomer), its sodium salt, its trifluoroacetate, its pivaloyloxymethyl ester, and its (5-methyl-2-oxo-1,3-dioxolene-4-yl)-methyl ester;

7-[2-carboxymethoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, trans-isomer, or syn-isomer, cis-isomer) and its trifluoroacetate;

7-[2-t-butoxycarbonylmethoxyimino-2-(2-tritylaminothiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, trans-isomer, or syn-isomer, cis-isomer); and

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(2-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, trans-isomer, or syn-isomer, cis-isomer), its sodium salt, its trifluoroacetate, and its (5-methyl-2-oxo-1,3-dioxolene-4-yl)-methyl ester.

13. A compound as claimed in Claim 1 in which is selected from:-

7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(4-chlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (cyn-isomer, cis-isomer), its sodium salt and its pivaloyloxymethyl ester; and

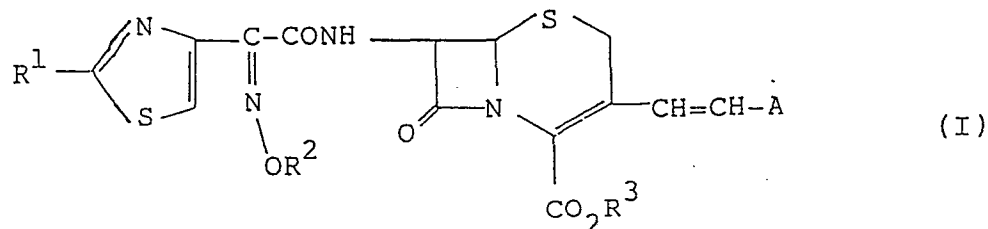
7-[2-methoxyimino-2-(2-amino-thiazol-4-yl)acetamido]-3-[2-(2,4-dichlorothiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, cis-isomer), its sodium salt and its pivaloyloxymethyl ester.

14. A compound as claimed in Claim 1 which is 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(3,4-dimethyl-5-thiazolio)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, trans-isomer, or syn-isomer, cis-isomer) iodide or di-trifluoroacetate.

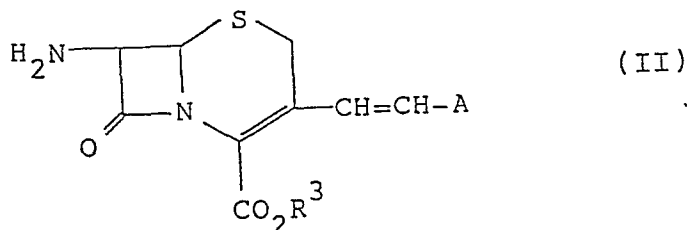
15. 7-[2-methoxyimino-2-(2-aminothiazol-4-yl)acetamido]-3-[2-(4-methylthiazol-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, cis-isomer) sodium salt.

16. 7-[2-methoxyimino-2-(2-aminothiazole-4-yl)acetamido]-3-[2-(4-methylthazole-5-yl)vinyl]-3-cephem-4-carboxylic acid (syn-isomer, cis-isomer) pivaloyloxymethyl ester.

17. A process for the production of a cepahlosporin compound of the general formula (I)

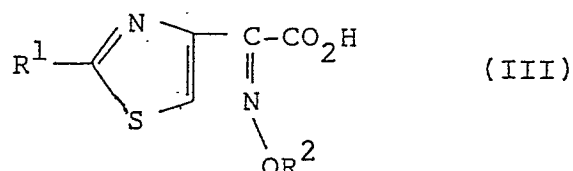


wherein R^1 is an amino group or a protected amino group, R^2 is a lower alkyl group, a carboxymethyl group or a protected carboxymethyl group, R^3 is a hydrogen atom, a salt-forming cation or a carboxyl-protecting group, and A is an unsubstituted or substituted phenyl group, an unsubstituted or substituted furyl group or an unsubstituted or substituted thiazolyl group or an unsubstituted or substituted 3-lower-alkylthiazolio group, characterized in that the process comprises reacting a 7-aminocephalosporanic acid compound of the general formula (II)

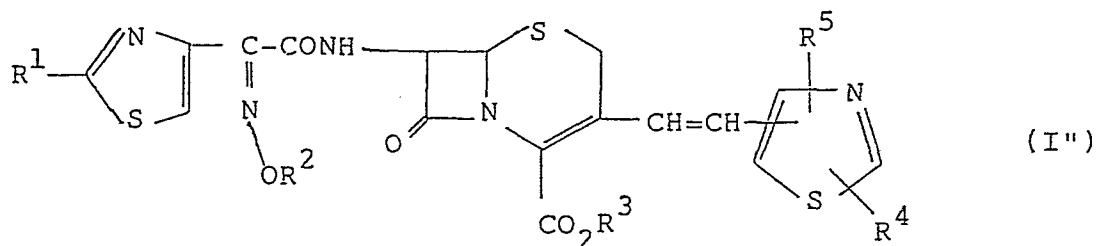


wherein R^3 and A are as defined above, or a functional equivalent thereof (including a reactive derivative at the amino group of the compound of the formula (II) and a salt

of the compound of the formula (II)), with a 2-(2-amino-thiazol-4-yl)-2-alkoxyimino-acetic acid compound of the formula (III)

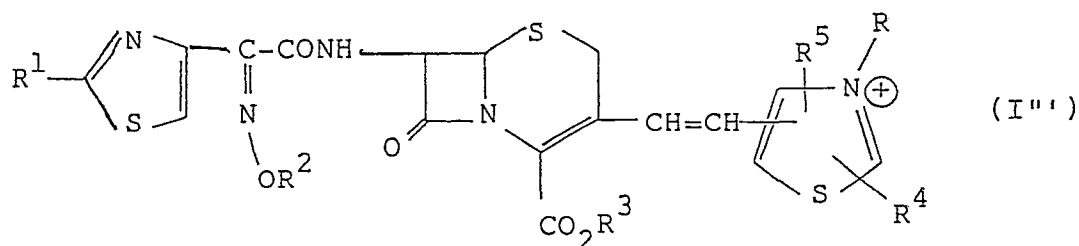


wherein R^1 and R^2 are as defined above, or a functional equivalent thereof (including a reactive acid derivative of the compound of the formula (III)) in an unreactive solvent at a temperature of not higher than the boiling temperature of the solvent used, to produce the compound of the formula (I), and then, if desired, where the product compound of the formula (I) as produced is such one as shown by the formula (I'')



wherein R^1 , R^2 and R^3 are as defined above, and R^4 and R^5 are the same or different and each are a hydrogen atom, a lower alkyl group or a halogen atom, alkylating the 3-nitrogen atom of the thiazolyl group of the compound

of the formula (I'') by reacting with an alkyl halide of the formula RX wherein R is a lower alkyl group and X is a halogen atom, or a mono- or di-lower-alkyl sulfate or a lower alkyl lower-alkanesulfonate, to produce the compound of the formula (I''')



wherein R^1 , R^2 , R^3 , R^4 and R^5 are as defined above and R is corresponding to the lower alkyl group of the alkyl halide or the mono- or di-lower-alkyl sulfate or the lower alkyl lower-alkanesulfonate employed, and further, if desired, removing the remaining amino-protecting group and the remaining carboxyl-protecting group from the product compound of the formula (I) or of the formula (I''').

18. A pharmaceutical, antibacterial composition which comprises an antibacterially effective amount of the compound of the formula (I) as defined in Claim 1 or the compound of the formula (Ia) to (If) as defined in Claims 2 to 7 or a pharmaceutically acceptable salt or ester thereof, as the active ingredient, in combination with a pharmaceutically acceptable carrier for the active ingredient.